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The Construction of the Buffalo Water-Works Tunnel and Intake Crib.

By C. H. HOLLINGSWORTH.*

The city of Buffalo is situated at the lower end of Lake Erie and along the east side of the Niagara River, which flows out of the lake. Up to the present it has secured its water-supply from two intake tunnels, leading from a small crib, located in the Niagara River, to a pumping station on the river bank. Some years ago, after an extensive investigation by a Board of Consulting Engineers, it was decided to abandon this tunnel and intake crib, first, because it is so located that part of the water from numerous brooks, etc., draining a thickly populated area, finds its way to the intake, and second, because it is located in the swiftest part of the river and is in great danger from boats. It was decided to construct a new intake crib in Lake Erie about 6,000 ft. from shore, build a new pumping station, drive a tunnel from this pumping station to the new crib, retain and improve the present pumping station and connect it with the new intake tunnel at the new pumping station by means of a land tunnel about 4,300 ft. long.

Fig. 1 shows the layout of the site with the old and new construction. At the upper part of the map is shown the old intake crib and pumping station. At this pumping station, Shaft. No. 1 was sunk and from it the Land Tunnel runs south to the new Porter Avenue Pumping Station, with Shaft No. 2 midway and Shaft No. 3 at the new pumping station. From Shaft No. 3 the Lake Tunnel was run to the Intake Crib far out in Lake Erie.

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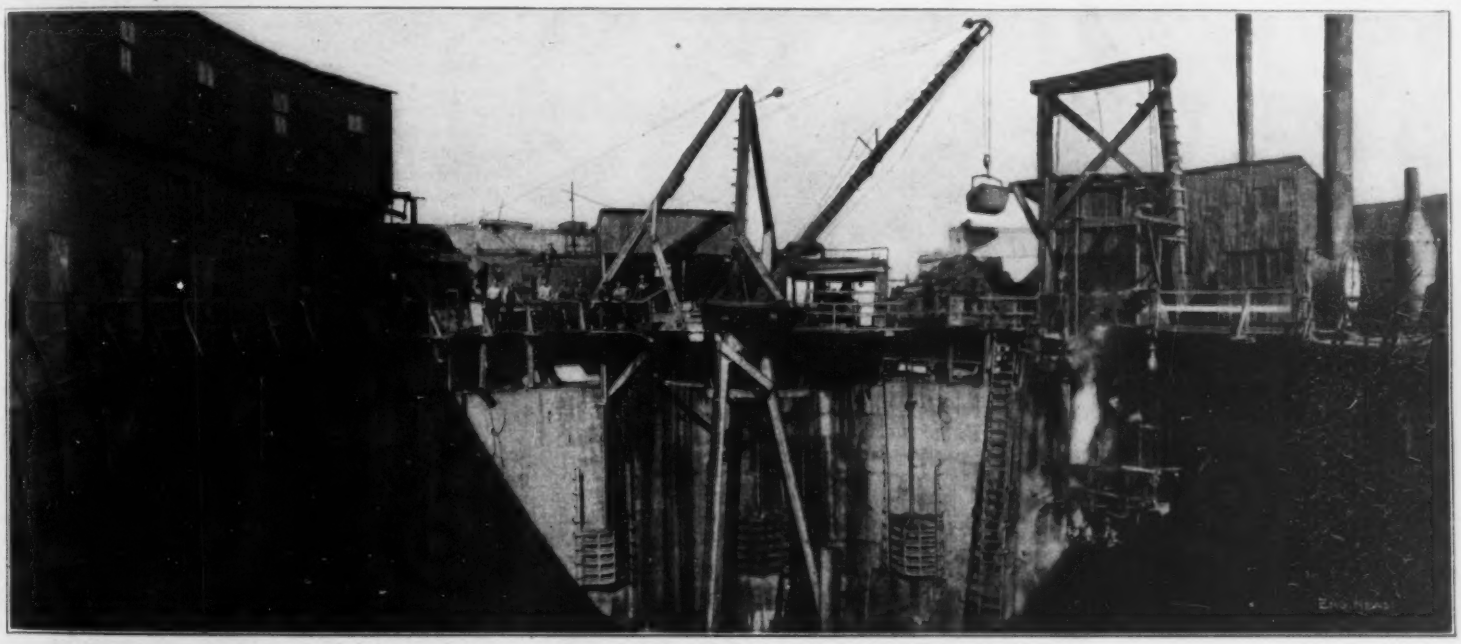
DESIGN.

The sections of tunnel are shown in Fig. 2. The Land Tunnel is practically rectangular, being about 7 ft. 6 ins. by 9 ft. inside with a 12-in concrete floor reinforced with ¾-in. square rods across the tunnel every 12 ins. These rods are 4 ins. below the top of the floor. The side walls are 18 ins. thick without reinforcement and the roof 12 ins. thick at the center and 18 ins. thick at the sides. This makes the excavation exactly 12 ft. wide by 10 ft. high. The Lake Tunnel is 11 ft. 3 ins. high by 12 ft. wide, inside the lining, which consists of an 18-in. floor, 18-in side walls and a 24-in. roof. The latter is an arch with 2-ft. rise and 10 ft. 2⅝ ins. radius. The floor is reinforced by 1 in. square rods, 4 ins. below its top, running across the tunnel every 12 ins. but the roof and sides are not reinforced.

The Intake Crib (Figs. 3-4) consists, first, of two concentric steel rings made up of ¾-in. steel plates riveted together and resting on a ring of concrete about 6 ft. deep, placed on the rock bottom. The top of the steel reaches a point about 3 ft. above water level. The space between the rings is filled with mass concrete even with the top of the steel shell and on top of this are placed concrete blocks carrying the outside up to 25.23 ft. above lake level, and the inside 13.23 ft. above lake level. The outside shell is 110 ft. in diameter and the inner shell is 70 ft. in diameter, leaving 20 ft. between the shells. The two rings are connected by 12 stiffening bulkheads. Twelve ports, each 6 ft. square and closed on the inner end by sluice gates, run through from outside to inside to admit water. The entire crib is covered by a brick and steel building, which houses the gate-operating mechanism, provides quarters for the men, etc., and on top is a small light for the guidance of ships.

In January, 1907, the contract for the entire Tunnel and Intake Crib was awarded to the Buffalo Dredging Co., of Buffalo, N. Y., and some preliminary work was started in March, 1907. Both the Land Tunnel and the Lake Tunnel are in rock, and, while a fixed grade was provided, it was understood that the contractors could decide for themselves at what level to drive the tunnel, provided they kept the roof at least 40 ft. below mean lake level. This allowance was made, because the rock in which the tunnel is located lies in horizontal strata and the seams between some of the strata carry a great deal of water, while in other levels there may be a belt of 20 ft. or more which is perfectly dry.

A diamond drill hole was put down at Shaft No. 2, in order to determine the driest strata in which to drive the tunnel. This drill hole and others made at Shaft No. 3 developed the fact that there practically was no dry belt of sufficient depth in which the tunnel could be located nearer than about 300 ft. below the surface. It was considered inadvisable to go to that depth, since in case water was struck it would be



VIEW OF INTERIOR OF INTAKE SHAFT IN LAKE ERIE DURING CONSTRUCTION.

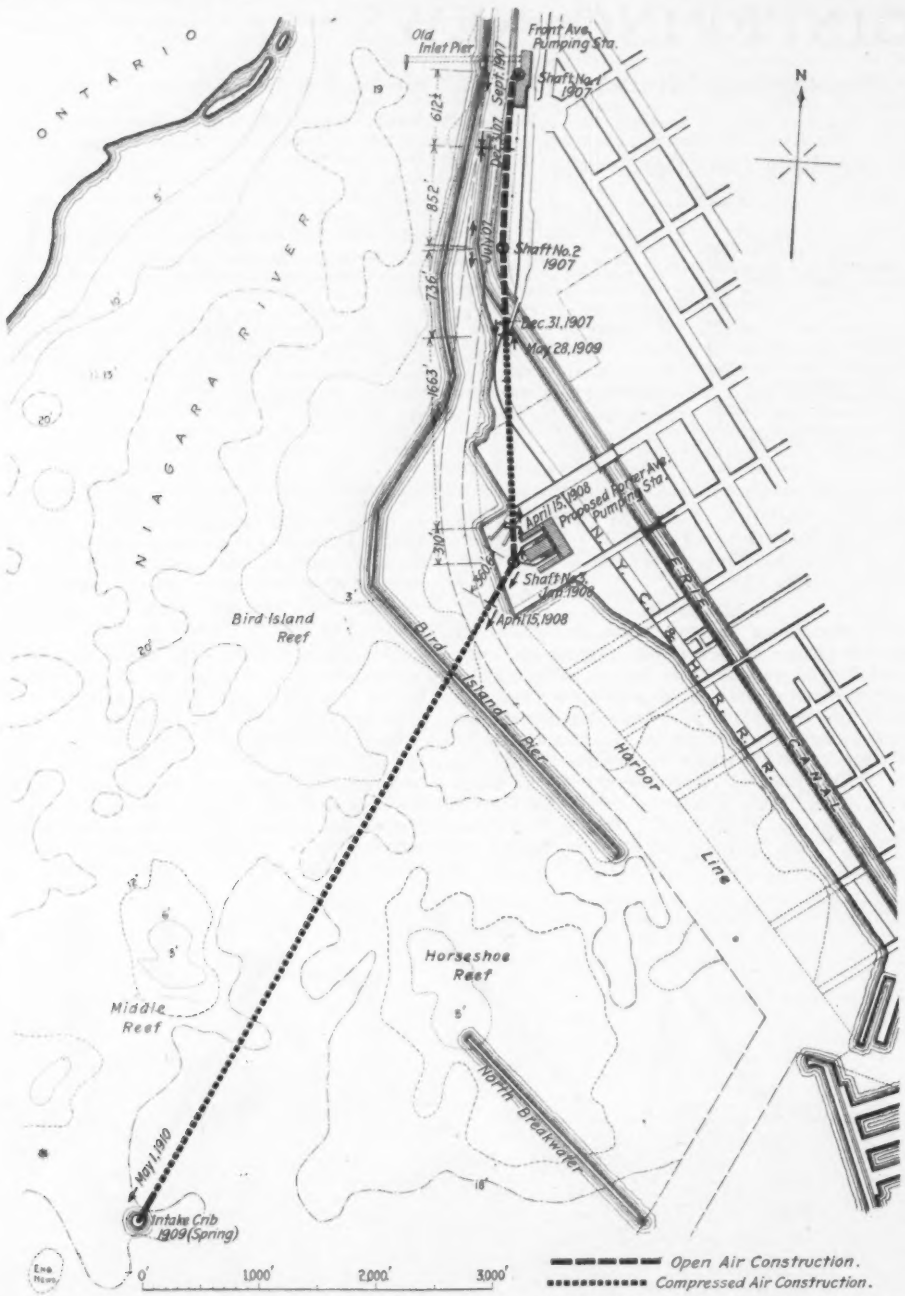


FIG. 1. GENERAL LAYOUT OF WATER-WORKS TUNNEL AND INTAKE SHAFT AT BUFFALO, N. Y.

too deep to use compressed air. Therefore, the next best level was selected, which, at Shaft No. 2, placed the bottom of the tunnel about Elev. 520.5, with a 0.2% rising grade toward Shaft No. 1, making the bottom of the latter Elev. 523.6, while mean water level in the adjacent canal and lake is approximately Elev. 572.77.

The tunnel was designed to be lined throughout with concrete so as to present a smooth surface to the water and to prevent what little seepage there might be. The difference in head between the water outside the tunnel and that inside would be so slight that the lining was reduced to a minimum. The inside area of the Lake Tunnel was 128.66 sq. ft. The concrete lining, as designed, was 6 ins. thick in the floor and 12 ins. on the sides and roof. When about 300 ft. of this section had been built it was found necessary to put on compressed air. The engineers feared that variations in the air pressure would cause undue hydrostatic pressures from the outside and so the lining thickness was materially increased without reducing the inside area. The side walls were made 18 ins. thick, the arch 24 ins. thick, as the rock was very seamy and dangerous in places, and the floor, where the greatest outside pressure would come if the air pressure went down for any cause, was increased to 18 ins. thick, reinforced with 1-in. square rods running across the tunnel, spaced 12 ins. apart. The lining of the Land Tunnel was thickened for the same reason as that of the Lake Tunnel and at the same time the cross section was made almost rectangular instead of with an arched roof, so that the lay of the rock, which was in horizontal strata, could be taken advantage of in the tunnel roof.

The practically rectangular shape of these tunnels was a great advantage in the driving of them, affording room for two tracks where needed and enabling the use of a maximum number of muckers.

Shaft No. 3 (at Porter Ave., Fig. 5) served as an uptake shaft connecting with covered canals which supplied the Porter Ave. Pumping Station. This shaft is rectangular, 14 ft. × 13 ft. 1 in. inside the concrete lining, which is 12 ins. thick. The tunnel changes here from the larger to the smaller section. The entrance to each tunnel can be closed by means of four sluice gates (two for each tunnel) operated from the top by means of gate stems and winches. The canal to the pumping station, which enters the shaft about at the rock surface, can also be shut off by means of a sectional gate sliding in a groove located about 50 ft. from the shaft.

Shaft No. 2 was a construction shaft only and was closed up by sealing it at the tunnel roof with 6 ft. of concrete.

Shaft No. 1 (Fig. 6) is at the Front Ave. Pumping Station and serves as an uptake shaft for this plant. It is connected with the pump wells by means of a covered canal which can be closed by a sectional gate about 15 ft. from the shaft. The shaft itself is lined with 12 ins. of concrete and is 10 ft. square and is covered over with a 6-in. reinforced-concrete roof at ground level, through which is a 30 × 24-in. manhole for inspection purposes.

The Lake Tunnel from Shaft No. 3 to the Intake is straight as is the Land Tunnel from Shaft No. 3 to Shaft No. 2. At Shaft No. 2 there is an angle in the line and the line from there to No. 1 was intended to be straight but was deflected to pass clear of the Front Avenue Pumping Station and enters Shaft No. 1 on its west side on a curve with a 36-ft. radius and having a 90° central angle. If the line had been run as originally intended it would have passed under a 250-ft. brick chimney and the boiler house and it was feared that the blasting might damage the chimney or, worse still, break some of the steam connections in the boiler house. As this is the one and only plant on which Buffalo depends for water it was thought best to take no chances that could be avoided.

LINE AND GRADE WORK.

The tunnels were first laid out on the surface and all measurements on land triangulated and chained in order to check them and all shafts excepting the Intake located and referenced. The position of the Intake was determined by triangulation, as was also a point on the line of the Lake Tunnel about 1,100 ft. from Shaft No. 3, toward the Intake, where it crossed the breakwater. When the Intake Crib was ready to be placed it was located by two instruments from two triangulation points and independently checked by an instrument on the tunnel line and then sunk in place.

After the various shafts had been sunk the tunnel lines were started in the usual way with plumb bobs and then checked by set-ups on opposite sides of the shaft from which sights were taken along the tunnel lines and points set at the bottom of the shaft. This gave a first-rate check on the lines.

When the driving of the tunnels was well under way the engineers set center plugs from 30 to 40 ft. apart. These plugs were put in, when needed, about 6 ft. back of the face of the heading in the following manner: The engineering party usually came in about 11.30 a. m. and, after enough muck cars had been run in to the bench to last the "muck gang" until noon, a set-up was made under the next to the last center plug in which was a small tack with a staple over it for hanging a plumb-bob. A sight was taken on the next center plug back of it and a chalk mark given in the heading for a line. By

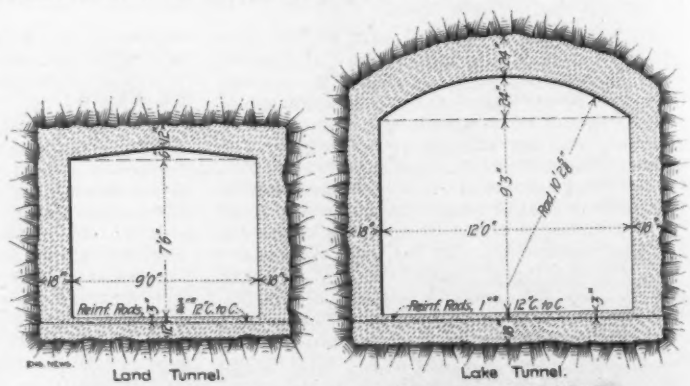


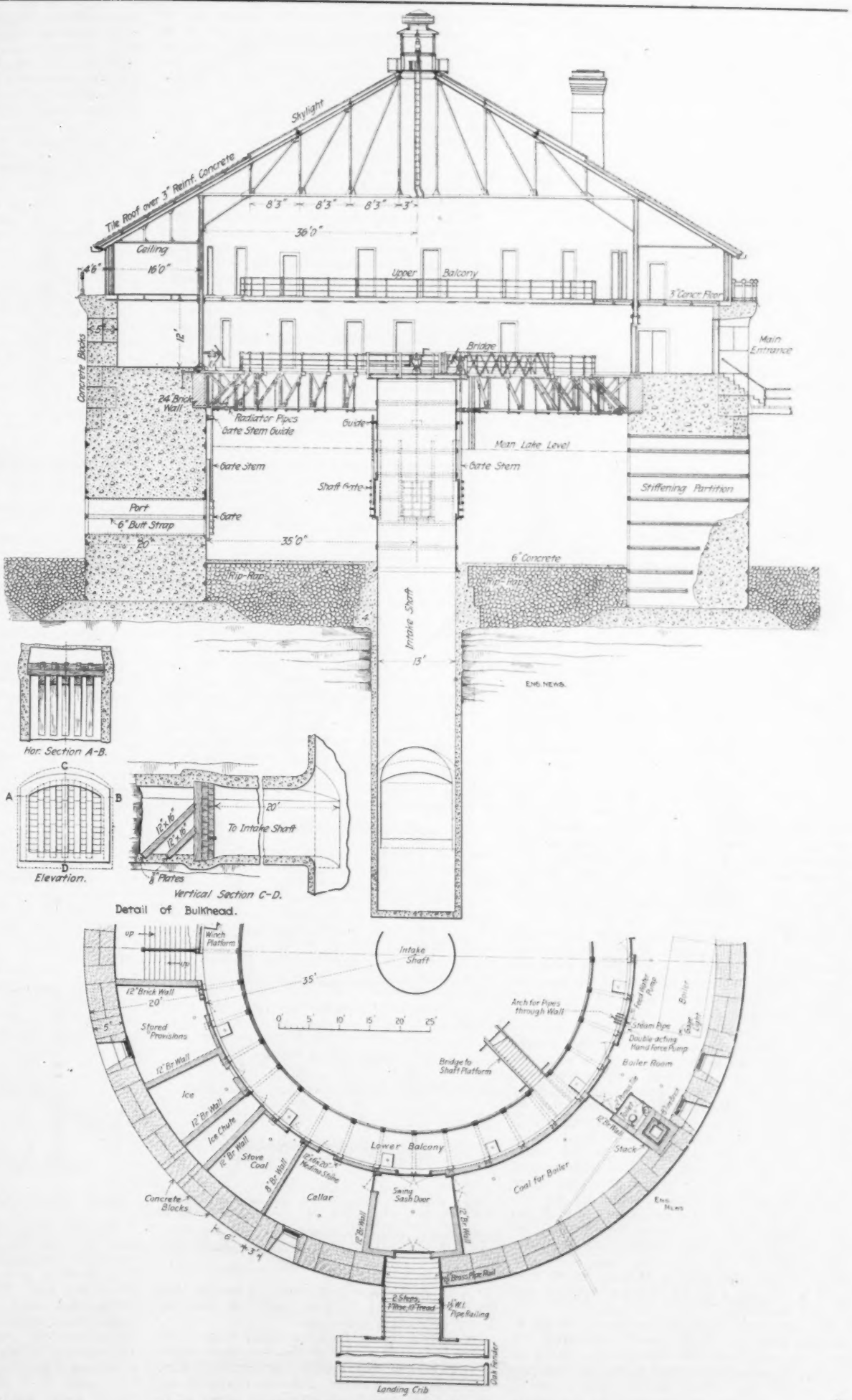
FIG. 2. SECTIONS OF LAND AND LAKE TUNNELS.

this time it was noon and one of the drill runners was detailed to drill a hole for the new plug, using a small drill on a special mounting designed for the purpose. While this was being done and the plug, which was 6 ins. long, driven in, the engineers had been taking center for a tack on the next plug ahead of their setup. The new plug was left without any center point on it other than a screw eye on which to hang a plumb bob in taking line in the heading. When the engineers came in to set their next plug the one back of it was centered, and so on. In this way the center line was kept close to the heading for the use of the contractors in driving while the exact center for the engineers was kept back so it would not be displaced by flying rock. As the heading was usually 300 or 400 ft. ahead of the concrete there was plenty of chance to keep the center checked up. A final line was carried in the finished concrete section with plugs about 200 ft. apart. Elevations were also given on every plug as fast as placed.

By the method just described the engineers usually accomplished their work in the heading during the half hour for lunch and did not delay the contractor's men. The results of their work in the checking up of the lines when the headings were holed showed remarkably well.

CONSTRUCTION.

The contractors' initial plan of construction was as follows: First, to install a main power plant at Porter Ave. and the crossing with the New York Central R. R. tracks, placing enough units in both boiler and compressor plants to handle work at Shafts No. 1 and 2, connecting the latter with the power plant by a pipe line; second, to commence tunneling simultaneously from Shafts No. 1 and 2, driving south from No. 1 and both north and south from No. 2; third, to start with a different organization the work of sinking Shaft No. 3, which was located about 500 ft. out in the Lake from the then shore line; and fourth, to start the placing of the Intake Crib the next season. This program was carried out and the shaft sinking at No. 1 and



FIGS. 3 AND 4. SECTIONAL ELEVATION AND PART PLAN OF INTAKE CRIB.

2 began in the Spring of 1907. Little trouble was encountered in these shafts except for the presence of considerable water from seams in the rock. Tunneling was started both ways from No. 2 in July and south from No. 1 in September, 1907.

Land Tunnels Under Free Air.

As shown on Fig. 1, the tunnel between Shafts 1 and 2 was carried through under free air, meeting some 852 ft. from Shaft No. 2 on Dec. 31, 1907. The tunnel south from Shaft No. 2,

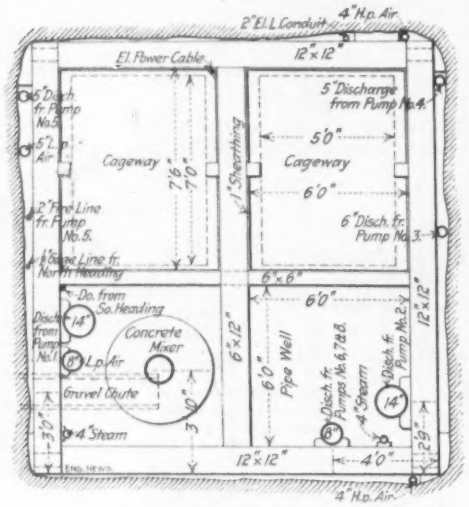


Fig. 5. Section of Shaft No. 3, Porter Ave. Pumping Plant.

was carried for 736 ft. under free air but was discontinued and bulkheaded about Dec. 15, 1907, on account of the excess of water. The tunnels in both directions from Shaft No. 3 were carried forward for a short distance under free air but were soon put under pressure and the holing through of the remainder of the Land Tunnel and the entire Lake Tunnel was completed under compressed air.

The method of working in the Land Tunnels in free air was about the same at all points of attack, as described below.

The entire tunnel section 10 ft. high × 12 ft. wide was carried forward at once, using two 8-ft. columns and four drills, following the scheme of drilling shown in Fig. 7. The columns were set up on enough muck to bring their top to a bearing against the roof. The lower holes were given enough inclination downward so that the bottoms of them were within a few inches of tunnel grade.

The gangs were worked two 10-hour shifts and usually drilled and fired the headings every shift except at Shaft No. 1, where the proximity to the Pumping Station made it necessary to shoot only a few holes at one time.

The mucking at Shaft No. 1 was done by loading the muck into 1-yd. dump buckets placed on flat cars. The latter were then pushed to the shaft by hand, picked up by a derrick and dumped into a bottom dump scow which laid in the River about 30 ft. from the shaft.

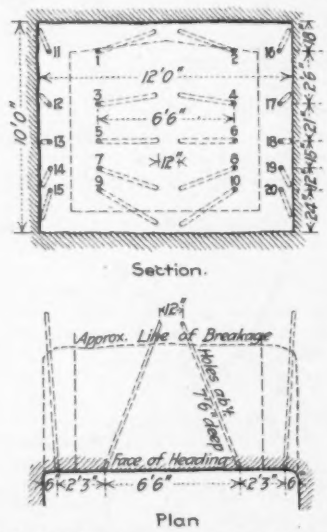
At Shaft No. 2 a cage was installed after the headings were in about 200 ft. each way and 1-cu.-yd. steel side dump cars were used. These cars were handled singly both in the tunnel and on top, by mules. The hoisting engines at Shafts No. 1 and 2 were operated by steam generated by small boiler plants at the respective shafts and the pumps which were run by compressed air were kept from freezing up by occasionally turning steam through them. The gang in each of the headings was made up as follows: One heading foreman, 4 drill runners, 4 helpers, 1 nipper, 1 muck foreman and 7 to 9 muckers.

No very fast progress was made, owing to several kinds of trouble which developed. A great deal of water was encountered, which, in addition to retarding the work, was so cold that the powder was chilled after it was placed in the holes. A very powerful exploder was finally found to be the only remedy for this. The water frequently forced the powder out of the bottom holes and wooden plugs had to be driven in to hold both powder and tamping in place. Another serious trouble met with was a sulphurous gas emanating from the water-bearing seams in the rock. This gas affected the men's eyes, often totally blinding them for some days. In spite of the fact that spare men were kept on hand, only part of a gang could often be raised. There was no way to get rid of this gas, although it was noticed that when this section of tunnel was concreted under air pressure no gas was found.

Another trouble was with ventilation. This problem was solved by using a well drill to sink 8-in. holes, spaced about 300 ft. apart along the tunnel line and connecting fans with these holes. The fans sucked the smoke from the headings back to the air hole, and then forced in air, which together with the compressed air blowing from the supply pipe, cleared the smoke back to the shaft. Another difficulty encountered was the rock formation which, although fairly good drilling material, laid in belts from 6 ins. to 2 ft. thick, often with a hard belt and a soft one next to each other. As it was impossible to put in the holes so as to avoid the seams the drill steel always jammed when crossing one and caused delays.

The headings between Shafts No. 1 and 2 met on Dec. 31, 1907, and about the same time so much water was struck in the south heading from Shaft No. 2 that it was decided to discontinue work there and finish the remainder of the work from Shaft No. 3. Work on the latter had previously been started by placing a timber crib 32 ft. square in the water and sinking it to bed rock by dredging out inside. Meantime a roadway was built out to it from shore by a dredge taking a cut and casting over. Buildings were erected around the shaft, a boiler plant of 400 HP. (later enlarged to 475 HP.) was installed and the crib pumped out and braced diagonally at the corner. By this time the work at Shafts No. 1 and 2 had been closed up. The last thing done there was to trim the entire 2,200 ft. of tunnel to full section and construct a concrete bulkhead about 250 ft. from the face of the south heading at Shaft No. 2.

SHAFT NO. 3.—Early in January, 1908, the sinking of Shaft No. 3 was started and very good progress was made. The shaft was sunk



First Shot.—Holes Nos. 3, 4, 5, 6, 7, 8, 9 and 10—Cut.
Second Shot.—Holes Nos. 12, 13, 14, 15, 17, 18, 19 and 20—Side Round.
Third Shot.—Holes Nos. 1, 2, 11 and 16—Dry Holes.

Fig. 7. Location of Drill Holes in Heading of Land Tunnel.

17 × 16 ft., being a foot larger all around than required, in order to have plenty of room for pump discharges, cages, etc.

In sinking the shafts three water seams were struck. As soon as one of these was disclosed by a drill hole it was grouted, as follows: Four holes, one at each corner of the shaft, were drilled to the seam and fitted with short pieces of 2-in. pipe, on top of which were screwed 2-in. stop cocks. The holes were grouted from a grout machine on top through a 2-in. hose and after each batch the stop cock at the hole was shut off. If the holes took the grout freely batches mixed of 1 cement to 2 sand were first used and mixed quite thick. Later on, when the seam began to plug up, a 1:1 mixture was

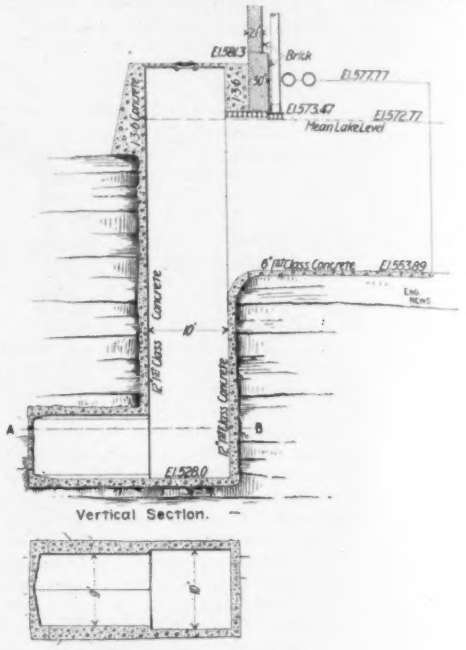


Fig. 6. Section of Shaft No. 1.

used, mixed very thin. One seam took 600 cu. ft. of grout before it could be plugged.

After the seam had been grouted it was allowed to stand for 24 hours and the shaft sinking was resumed. The shaft was excavated by one drill gang working nights (10 hrs.) and one muck gang working days. The first night the drillers drilled the cut and one or two side-round holes and fired the cut. The next day the muck gang cleaned up the muck from the cut, refiring it if necessary. The second night the drillers finished drilling the side-round and fired

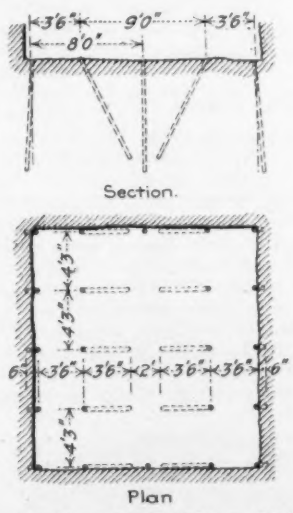


Fig. 8. Location of Drill Holes in Shaft No. 3.

it and the muck gang cleaned it up the following day. In this way the drillers could get a 10-ft. round each time and each shot averaged about 8 ft. or 46 ft. in 6 shots, and the progress ran 3.8 ft. per day. The entire shaft was sunk in 12 working days. Drills mounted on tripods were used, it being necessary to lay some timbers across the cut while drilling the side-round. The spacing of the drill holes in this shaft is shown in Fig. 8.

A sump was excavated 8 ft. below the tunnel grade and the full size of the shaft. Two pump chambers, each 17 ft. wide and

12 ft. high and 20 ft. long, were excavated on opposite sides of the shaft with their floors about 6 ft. above tunnel grade. In these were installed pumps with a capacity of 8,380 gals. per minute operated by steam at 120 lbs. pressure from the boiler plant at the shaft head. The shaft was timbered up in three compartments. Two of these accommodated two 7 × 5-ft. balanced cages and the third compartment was for pump discharges, concrete mixer, steam lines, air lines, etc. The sump was timbered over and all pump exhausts discharged into it.

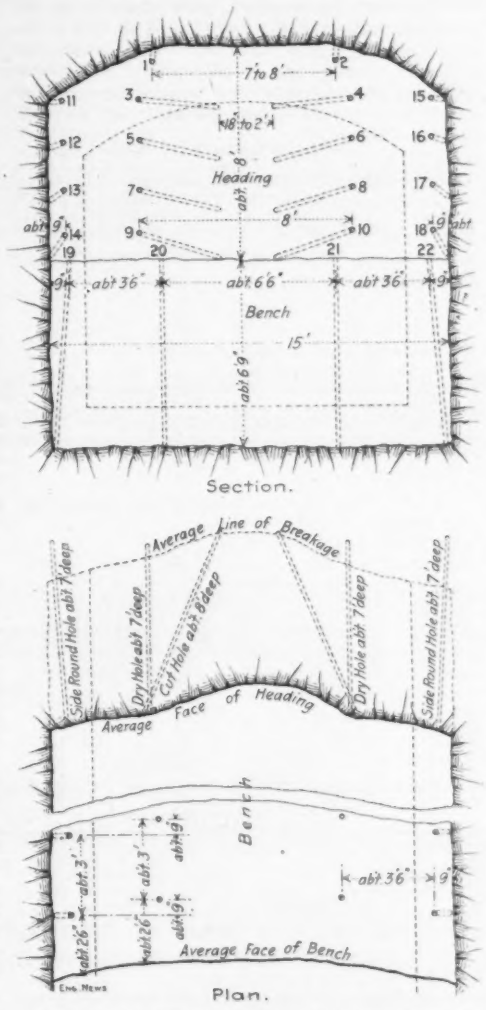
Both tunnel headings had reached only about 300 ft. from the shaft before so much water was encountered that it became necessary to put on compressed air. Air locks were installed in both tunnels and about April 15, 1908, the pressure was applied, giving about 18 lbs. in the Lake Tunnel and about 12 lbs. in the land section. This helped matters but the compressor plant was not of sufficient size to get the pressure any higher, owing to the presence of numerous leaks in the tunnels. As the methods of working were radically different in the two tunnels they will now be described separately.

Lake Tunnel.

After turning the air pressure on this tunnel it was found that the worst water seam was about 6 ins. above the grade of the tunnel roof, running down at about a 1% grade as the tunnel progressed. The air pressure was not enough to hold the water and the leak was getting worse as the tunnel advanced, as the plant for concreting was not then on the ground. Accordingly, a bottom heading the full width of the tunnel and 7 ft. high was carried forward about 500 ft., pending the arrival and installation of the concrete plant. Holes were drilled in the top of this heading until the water seam was struck. These holes were about 15 ft. apart and on alternate sides of the tunnel. Grout mixed 1 cement to 2 sand was then pumped into the holes until they were full. The upper part of the tunnel section was then removed by drilling from a heavy timber staging which was advanced as the drilling progressed. (Fig. 10.) Two of these stages were used, each made up of two 16-ft. sections, one starting at the beginning of the bottom heading and the other at a point halfway in, and both moving in the same direction.

The drilling was done with two machines on short columns, the holes running horizontally and parallel with the center line of the tunnel. One round of holes was fired as each shift went off duty. The shift coming on always found one stage cleared off and ready for them to set up on while the muck shift coming on found one stage full of muck. This they rolled down into cars. The stage was moved ahead 16 ft. every two shifts.

The progress made on the upper half of the tunnel in the above manner ran as high as 150 ft. in one week, but when it is taken into consideration that, when the bottom heading was



First Shot.—Holes Nos. 3, 4, 5, 6, 7, 8, 9 and 10—Cut.
—Holes Nos. 19, 20, 21 and 22—Bench Holes.
Second Shot.—Holes Nos. 1 and 2—Dry Holes.
—Holes Nos. 11, 12, 13, 14, 15, 16, 17 and 18 Side Round.

Fig. 9. Location of Drill Holes in Heading of Lake Tunnel

driven, it advanced at the rate of 70 to 77 ft. per week the progress does not show up so well.

When the full tunnel section had been excavated to the end of the bottom heading, the concrete plant was in operation and the tunnel was then concreted up to within 60 ft. of the face. The excavation was then renewed, but although more compressors had been installed the water still gave trouble. Grouting was the only sure method of stopping the water and after experimenting in several ways it was found that after the main water seam was exposed along the sides of the tunnel it could be grouted and closed with a few batches of grout by running holes 6 or 8 ft. deep straight into the seam. These holes were spaced about 15 ft. apart along each side of the tunnel. The most peculiar thing about this was, that it was very seldom that any grout came out of the seam along its exposed face and when it did a little oakum pushed into the seam quickly stopped it. In this way the water was cared for until about 1,800 ft. from the shaft where the heaviest water seam dipped down below the grade of the tunnel. After that the tunnel was quite dry but whenever the pressure ran down to 22 lbs. the water would run from numerous small seams.

From this point on the tunnel was carried on by means of a top heading and bench. The heading was about 9 ft. high in the center and 15 ft. wide and was drilled with a center cut and a single side-round and two dry holes. (Fig. 9.) This was finally decided upon as the method best adapted to this work. The rock was black flint so hard that it would readily cut window glass and somewhat blocky, so that it would be impossible to drill more than the above number of holes (viz. 18) in one shift and it was only by the closest margin that the 18 were drilled and fired in 8 hrs. The bench was taken up with a row of four holes with the rows spaced about 3 ft. apart. The bench was kept within 20 to 50 ft. of the heading at all times and the concrete was kept within about 300 ft. of the bench. Air was supplied for the drills, four in the heading and two on the bench, by a 5-in. high-pressure air line running up to the concrete forms and a 3-in. line running from there to the heading, terminating in a 30-ft. length of 3-in. armored hose with a seven-branch manifold on the end. The high-pressure air compressors carried from 125 to 130 lbs. pressure at the Power House and the pressure in the heading was from 85 to 90 lbs. A water jet was used to jet the cuttings out of the holes and as the rock was hard and cut slow, one jet served for the four heading machines and a second one for the bench. The jets were made of ⅜-in. pipe supplied by a ¾-in. hose. The water for this purpose was furnished by a pump at the shaft through a 2-in. line to a point near the bench from where a 1-in. pipe ran into the heading. The muck was handled as follows. The muck from the heading was loaded into ½-cu.-yd. rotary-dump, 18-in. gage cars running on tracks made up in 12-ft. sections, which ran out on supports over the tunnel cars. These cars were steel with V-shaped bodies holding 1 cu. yd. The small heading cars were loaded, run out by one man, as the track had a slight incline away from the heading, dumped into the larger cars and returned for another load, the round trip occupying about one minute or less. The muck in front of the bench was shoveled directly into the tunnel cars which were set in trains of three. The front car was filled from the bench and the two rear cars from the heading. When the muck from the heading was cleared away (usually about 1 p. m.) the light track was removed back to the top of the

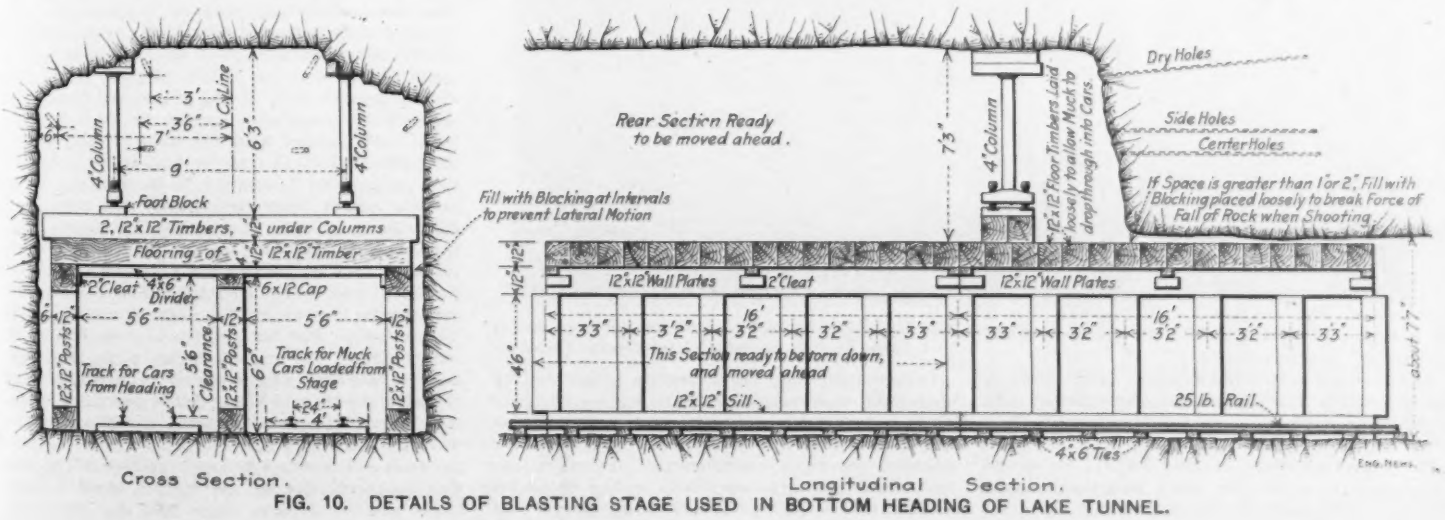

4"Column
Foot Block
2, 12"x12" Timbers, under Columns
Flooring of 12"x12" Timber
2"Cleat
4"x6" Divider
6"x12 Cap
Track for Cars from Heading
Track for Muck Cars Loaded from Stage
12"x12" Posts
Cross Section.
Rear Section Ready to be moved ahead.
Fill with Blocking at Intervals to prevent Lateral Motion
Dry Holes
Side Holes
Center Holes
If Space is greater than 1' or 2", Fill with Blocking placed loosely to break Force of Fall of Rock when Shooting
12"x12" Floor Timbers Laid loosely to allow Muck to drop through into Cars
12"x12" Wall Plates
2"Cleat
This Section ready to be torn down, and moved ahead
12"x12" Sill
25 lb. Rail
4"x6" Ties
Longitudinal Section.

FIG. 10. DETAILS OF BLASTING STAGE USED IN BOTTOM HEADING OF LAKE TUNNEL.

bench muck pile and the small car was employed on that until the end of the shift.

Back of the concrete forms in the completed tunnel was a side track about 100 ft. long for car storage purposes which was removed forward about once a month; nearer the heading at the concrete forms was a switch for cars of concrete (Fig. 11). Between the car storage siding and the heading the cars were handled by a 5-HP. storage-battery electric locomotive. This machine would take in three empties and return with three loaded cars, place the latter on the outbound side of the storage siding, take three empties from the inbound track and so on. It also handled cars of concrete from this siding up to the concrete forms.

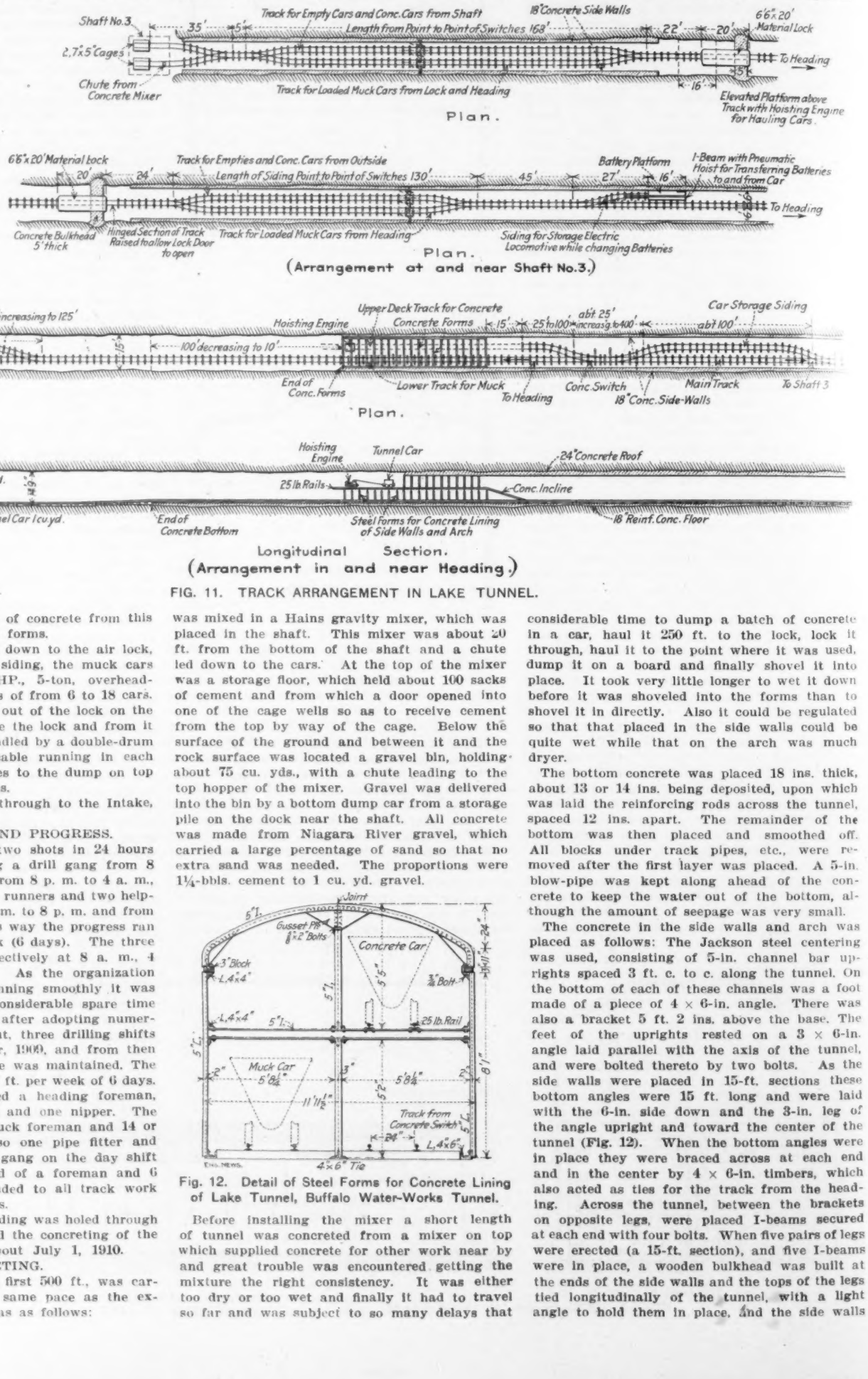


FIG. 11. TRACK ARRANGEMENT IN LAKE TUNNEL.

From the storage siding down to the air lock, where there was another siding, the muck cars were handled by a 30-HP., 5-ton, overhead-trolley locomotive in trains of from 6 to 18 cars. The cars were run in and out of the lock on the inside by hand and outside the lock and from it to the cages they were handled by a double-drum hoisting engine with a cable running in each direction. From the cages to the dump on top they were hauled by mules.

The heading was holed through to the Intake, May 1, 1910.

ORGANIZATION AND PROGRESS.

At first a schedule of two shots in 24 hours was arranged by working a drill gang from 8 a. m. to 4 p. m. and one from 8 p. m. to 4 a. m., with an extra crew of two runners and two helpers who worked from 4 p. m. to 8 p. m. and from 4 a. m. to 8 a. m. In this way the progress ran from 60 to 66 ft. per week (6 days). The three muck gangs started respectively at 8 a. m., 4 p. m. and 12, midnight. As the organization got shaken down and running smoothly it was noticed that there was considerable spare time on the drilling shift and after adopting numerous short cuts to help out, three drilling shifts were started in November, 1909, and from then to the finish that schedule was maintained. The progress ran from 85 to 97 ft. per week of 6 days.

The drill gangs included a heading foreman, 6 drill runners, 6 helpers and one nipper. The muck gang included a muck foreman and 14 or 15 men. There was also one pipe fitter and one electrician besides a gang on the day shift only which was composed of a foreman and 6 or 8 men and who attended to all track work and set up concrete forms.

As above noted, the heading was holed through to the Intake, May 1, and the concreting of the tunnel was completed about July 1, 1910.

CONCRETING.

The concrete, after the first 500 ft., was carried along at about the same pace as the excavation. The method was as follows:

On Sunday, the concrete gang cleared out all loose material in the bottom down to sub-grade and for the length of tunnel that would be concreted during the next week. The track from the heading was then blocked up and the concreting of the bottom began. All concrete was mixed in a Hains gravity mixer, which was placed in the shaft. This mixer was about 20 ft. from the bottom of the shaft and a chute led down to the cars. At the top of the mixer was a storage floor, which held about 100 sacks of cement and from which a door opened into one of the cage wells so as to receive cement from the top by way of the cage. Below the surface of the ground and between it and the rock surface was located a gravel bin, holding about 75 cu. yds., with a chute leading to the top hopper of the mixer. Gravel was delivered into the bin by a bottom dump car from a storage pile on the dock near the shaft. All concrete was made from Niagara River gravel, which carried a large percentage of sand so that no extra sand was needed. The proportions were 1¼-bbls. cement to 1 cu. yd. gravel.

Fig. 12. Detail of Steel Forms for Concrete Lining of Lake Tunnel, Buffalo Water-Works Tunnel.

Before installing the mixer a short length of tunnel was concreted from a mixer on top which supplied concrete for other work near by and great trouble was encountered getting the mixture the right consistency. It was either too dry or too wet and finally it had to travel so far and was subject to so many delays that the cement had its initial set before it was in place. Therefore, when the gravity mixer was installed it was decided to mix all concrete dry and wet it in the tunnel before placing in the forms. In this way no trouble was experienced. Out from the shaft 4,000 to 6,000 ft. it required considerable time to dump a batch of concrete in a car, haul it 250 ft. to the lock, lock it through, haul it to the point where it was used, dump it on a board and finally shovel it into place. It took very little longer to wet it down before it was shoveled into the forms than to shovel it in directly. Also it could be regulated so that that placed in the side walls could be quite wet while that on the arch was much dryer.

The bottom concrete was placed 18 ins. thick, about 13 or 14 ins. being deposited, upon which was laid the reinforcing rods across the tunnel, spaced 12 ins. apart. The remainder of the bottom was then placed and smoothed off. All blocks under track pipes, etc., were removed after the first layer was placed. A 5-in. blow-pipe was kept along ahead of the concrete to keep the water out of the bottom, although the amount of seepage was very small.

The concrete in the side walls and arch was placed as follows: The Jackson steel centering was used, consisting of 5-in. channel bar uprights spaced 3 ft. c. to c. along the tunnel. On the bottom of each of these channels was a foot made of a piece of 4 × 6-in. angle. There was also a bracket 5 ft. 2 ins. above the base. The feet of the uprights rested on a 3 × 6-in. angle laid parallel with the axis of the tunnel, and were bolted thereto by two bolts. As the side walls were placed in 15-ft. sections these bottom angles were 15 ft. long and were laid with the 6-in. side down and the 3-in. leg of the angle upright and toward the center of the tunnel (Fig. 12). When the bottom angles were in place they were braced across at each end and in the center by 4 × 6-in. timbers, which also acted as ties for the track from the heading. Across the tunnel, between the brackets on opposite legs, were placed I-beams secured at each end with four bolts. When five pairs of legs were erected (a 15-ft. section), and five I-beams were in place, a wooden bulkhead was built at the ends of the side walls and the tops of the legs tied longitudinally of the tunnel, with a light angle to hold them in place. And the side walls

were ready to concrete. The lagging used was of thin steel plates with a light 2-in. angle all around them. These plates were 3 ft. long by 12 ins. wide and the angles all faced toward the center of the tunnel, when in place. The first course of plates was placed, the end angles hooking over the flanges of the channel upright and the lower side of the plate resting on the

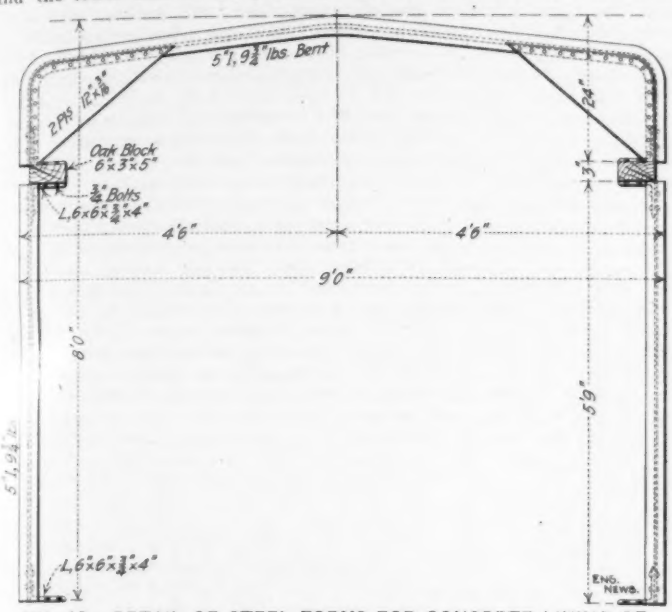


FIG. 13. DETAIL OF STEEL FORMS FOR CONCRETE LINING OF LAND TUNNEL.

bottom concrete. When the concrete had reached the height of the top of this row of plates another row was placed, etc. The concrete for about 4 ft. of the bottom of the side walls was dumped from the cars alongside the "muck" track, which was located here at one side of the tunnel.

The remainder of the side walls up to the top of the uprights was placed from the upper deck as follows: At a point back of the forms a switch was placed from the main track and leading toward the heading. This switch was moved up close to the forms every Sunday and the forward end of it terminated in an incline, which led up on to the tops of the I-beams, which held the side wall forms apart and supported the upper deck. The incline was made of 60-lb. T-rails with the lower end beveled to fit on the bottom track and the upper end hinged to a 6-ft. section of track, resting on the upper deck. The latter in turn was connected to a 24-in. gage track running across the deck beams toward the heading. The incline was 15 ft. long and the rise was 5 ft. 7 ins. The deck I-beams were further stiffened by placing a short 5-in. I-beam under their center as an upright. Steel plates ¼-in. thick were laid on the beams on which to dump the concrete. At the forward or heading end of the track on the upper deck was a small single-drum hoisting engine, mounted on a car. This engine was chained to the front I-beam to anchor it and a ½-in. cable, with a hook, was taken down the incline, hooked to a concrete car and the latter pulled up and dumped. The concrete was wet down and the side walls finished, after which the arch was concreted. The cars were lowered down the incline, switched to the main line and sent in to the heading for "muck". The arch ribs were built in two sections connecting in the center and supported there by an upright 5-in. I-beam. The ribs were made of 5-in. I-beams bent to fit the arch. At the haunches they had an angle-iron foot, which rested on the side-wall uprights. One rib was erected and all lagging placed after which the concrete was thrown in from the face and tamped back.

The forms were taken down in 15-ft. sections as follows: First, bolts were removed; then the packing blocks between arch ribs and uprights were knocked out, the ends of the rib sections dropped down 3 ins. and the center support of the ribs was knocked from under the joint in the center of the ribs, allowing one section to drop down. The support was then knocked toward the other side of the tunnel, allowing the last section and the upright to be removed. The lagging stuck to the concrete and, after the removal of the ribs, was taken down. The short section of track hinged to the incline was disconnected from the track on the upper deck, the incline raised up level and placed on a car. The upper deck beams were then removed, the car with the incline on it pushed ahead and connected to the upper track, the car run out from under it and it was then ready for use again. Next the side wall uprights were unbolted from the bottom angle and taken down, the latter removed and finally the lagging taken down and the entire section re-erected ahead of the concrete as described previously.

About the only trouble experienced with the steel forms was that they slightly overrun at the top so that about every 300 to 400 ft. a pair of legs and a rib would be plumbed up exactly perpendicular to the floor line of the tunnel and a set of ¾-in. wooden lagging sawed to fit between this and the next set behind. The overrunning was caused by concrete sticking to the legs and to the angles on the ends of the lagging and never amounted to more than from ½-in. to ¾-in. per 100 ft. Otherwise the steel forms and lagging worked admirably.

The concrete gang in the tunnel included one foreman and usually 6 or 7 men, and on the mixer two men only were necessary. When concreting side walls from down below, steel plates were put on the bottom concrete to shovel from and the entire gang shoveled with the exception of one man, who placed lagging and tamped the concrete. Two-car trains were pushed in and quickly dumped and scraped clean with hoes, after which the concrete was wet down and shoveled in. When concreting from the upper deck the foreman or one of the men ran the hoisting engine, which, of course, was used only intermittently. One man stayed at the incline to hook and unhook cars and shove the empties on to the main line. The other men shoveled in the concrete and tamped it. The arch ribs were erected by the concrete men themselves and the lagging put on complete, during which time concreting was stopped. The steel side-wall frames, bottom angles and I-beams for the upper deck were placed by an extra gang, consisting of a foreman and 6 men. This gang worked only on the day shift and also looked after all track work, moving switches, shifting concrete incline, trimming ahead of concrete, drilling holes for electric wires, and cleaning up from the bottom all loose concrete dropped in concreting side walls and arch. The switch connecting with the concrete incline was moved every Sunday, the "muck" switch in the heading was moved every Sunday and the car storage track located behind the concrete forms was moved about once a month. The concrete figured about 88 cu. ft. per lin. ft. but in practice overran about 20%. The average week's work for the concrete gangs ranged from 75 to 100 lin. ft. of tunnel per week. The surface of the concrete, when the forms had been removed, showed fairly smooth with the exception that the joints between the plates showed up, giving the tunnel the appearance of being lined with concrete blocks. Two men kept the surface smoothed up by plastering it.

SHORT CUTS.—During the course of the work the parties in charge studied the different operations closely with a view to saving time and in numerous instances made little changes that effected quite a saving in time. One point was the use of delay-action electric exploders in conjunction with the regular exploders in such a way as to cut down the time of firing from one and one-half hours to one-half hour, another point was the making up of the powder (60% dynamite) in cartridges 16 ins. long instead of 8 ins. long, thus facilitating the loading of the holes and also getting rid of considerable extra paper. Another point was the use of quick-action hose couplings which "made up" with ⅛-turn instead of screwing together. Sand for tamping the holes was put up in 16-in. paper sacks and sent in with the powder. All drills were repaired on top in the machine shop. Whenever a machine broke down it was loaded on top of a full muck car and sent out while a new one was substituted. Two or three extra machines were kept in the tunnel near the heading as was also a stock of chuck bolts, arm bolts, hose spuds, etc.

FIG. 14. VIEW OF SECTION OF LAND TUNNEL SHOWING STEEL FORMS.

Land Tunnel Under Air.

This section of the tunnel was in a different rock formation from the Lake section, as it was driven in a close-grained medium hard limestone the same as encountered at Shaft No. 1 and 2. Compressed air was turned into this tunnel at the same time as the Lake section but after reaching a point about 600 ft. from the shaft the leakage of air was so great that work was suspended for about four months during the installation of concrete mixing plant and additional compressors. During this time the heading was allowed to fill with water. After it was pumped out and work resumed the tunnel was carried along by the same method as used at the other shafts and the concreting followed along as rapidly as possible behind the excavation until the heading was holed through to the south heading from Shaft No. 2 on May 28, 1909.

Two shifts of drillers and three shifts of muckers were used on this work and the excavation progress ran from 60 to 86 ft. per week. The muck was handled by gravity from the heading down to the air locks, as the tunnel was on a 1% grade, and the empty cars and concrete were hauled up by means of a hoisting engine. There was a 24-in. single track from the air lock to the heading, short length of double track immediately behind the muck pile and a siding about 100 ft. long inside the air lock.

CONCRETING.

In concreting this tunnel, Jackson steel forms were used, consisting of two short legs of 5-in. I-beams and an arch rib of the same, spaced every 3 ft. with steel plates for lagging, the same as in the Lake section. (Figs. 13-14). The forms were set up in 15-ft. sections and the concrete dumped on steel plates, wet down and shoveled in. After the concrete lining had been carried up to the bulkhead which had been placed from Shaft No. 2, it became necessary either to take off the air entirely and pump all seepage and care for the additional leakage from the section previously driven while the latter was being concreted or else to bulkhead Shaft No. 1 and 2 and put air on that section while it was being lined. The latter scheme was adopted, as it was not thought advisable to subject the tunnel lining to an outside pressure of from 25 to 28 lbs. per sq. in. This plan had the further advantage that under it the air pressure would dry out the excavated section so as to admit of the concrete being placed properly.

The water in the flooded section was lowered and a 4-ft. concrete bulkhead built in Shaft No. 1 and 2. In these bulkheads were a 8 × 3 ft. vertical "Man Lock" and a 8 × 3 ft. concrete lock. It was intended to concrete about 1,500 ft. of the 2,200 ft. section from Shaft No. 2 and the remainder from Shaft No. 1, but the season was so far advanced when the locks had been placed that it was decided to concrete the entire section from shaft No. 2 as there was ample space for gravel storage there and a boiler plant to keep it thawed in cold weather.

The concrete plant at Shaft No. 2 was arranged as follows: Inside the concrete lock and directly under it was a Hains gravity mixer of ¾-cu.-yd. capacity discharging through a chute into cars at the bottom of the shaft. Outside, the gravel was shoveled into a bottom-dump 24-in. gage car which was pushed to the shaft head where after the cement had been spread on it, it was dumped into the concrete lock through a hopper and chute. The batch was wet in the mixer inside the lock. The concrete was hauled from the shaft along the tunnel by means of a 5-ton electric locomotive with overhead trolley. The tunnel floor was first laid working from the south end of the section north to Shaft No. 2 and then working from Shaft No. 1 south to Shaft No. 2. The side walls and roof were then built in the same order. Shaft No. 1 was lined up to the under side of the bulkhead and afterwards the section above the bulkhead and the canal leading to the Front Avenue Pumping Station was lined. As Shaft No. 2 was for construction purposes only it was blocked off with 6 ft. of concrete above the tunnel roof, reinforced with old rails, and the locks in this shaft were then removed.

Intake Crib.

The intake crib has already been described and Figs. 3-4 show the details clearly. The steel shell of the crib was constructed at the Buffalo Dredging Co.'s repair yard on the Buffalo River, at Ohio St. In constructing the crib, timber bottoms were built in eight of the twelve pockets in order to float it while being towed to position. In the Spring of 1908 the site of the crib was dredged down to solid rock and this was carefully cleaned by the dredge and examined by divers. Concrete was then deposited in a ring, the outside of which was about 120 ft. in diameter and the inside 60 ft. This concrete was about 6 ft. deep and after it had set, measurements and soundings were taken and at a dozen or more points a bucket of concrete would be deposited, which a diver carefully leveled off to a given grade, which was slightly above the general level of the other concrete. All concrete was deposited under water, using a bottom-dump bucket, which was lowered first to the bottom then raised just enough to clear the doors and then dumped. A piece of canvas was used to cover the bucket on top, one side being fast to the bucket. This prevented wash from the water rushing in, as the bucket dumped. All concrete was mixed on a floating plant, including one mixer boat, and a gravel scow. The mixer boat was a schooner equipped with a 75-HP. boiler aft, two stiff-legged derricks amidships and on opposite sides and a 1 cu. yd. cubical mixer forward, above which was a storage bin for gravel. There were also two hoisting engines to operate the derricks. One derrick, fitted with a 2-cu.-yd. clamshell bucket, kept the mixer supplied with gravel from the gravel scow and the second derrick handled the concrete as it came from the mixer.

When the foundation was completed the caisson itself was launched and towed by five tugs to its proper position, making the trip of about four miles in about five hours. When the crib was in its proper position the valves were opened and it sank until it rested on the foundation previously prepared. Concreting was immediately started in the pockets in which there were no bottoms and later on, when the timber bottoms had been removed, in the others. After the concrete had reached the top of the steel shell, forms were erected and it was completed, including the coping course, with the exception of a gap left on the side next to the landing crib, in which were to be located steps, entrance door, etc. Operations were then discontinued until the Spring of 1909 when work was started on the shaft.

The first step was to construct accommodations for the men and get plant out to the crib. Roughly, about one-half of the top of the crib was covered with a building for the accommodation of the men. The outer side of this building set on the coping course of the outside crib wall, while the inner side of the building rested on 6 × 6-in. posts, the bottoms of which set on the top of concrete of the main crib. The building was about 250 ft. long and 18 ft. wide and was divided into five compartments, dormitory for laborers, dining room for laborers, kitchen, dining room for mechanics, foremen, etc., and dormitory for mechanics and foremen.

In the plant on top of the crib was located an electric light plant, stiff-leg derrick for handling muck from the shaft, two boilers of 150 and 75 HP., feed pump for the boilers, pump for water-supply for the men and a coal storage bin holding about 50 tons. (See view on p. 153.)

While sinking the shaft steam at 100 to 120 lbs. pressure was used to run the drills. After turning the headings one of the air compressors from the Porter Ave. plant was brought out and set up on top of the crib. At the same time a blacksmith shop, pipe shop, oil house, powder magazine and coal storage bin of 150 tons capacity were built around the shaft inside of the crib. The shaft sinking was slow owing to several water seams which had to be grouted, to a scarcity of men and other reasons. On reaching tunnel grade a sump was first excavated and then both the headings were started. The south or west heading ran out from the shaft about 75 ft. and was bulkheaded off so as to admit of a future extension of the tunnel without discontinuing the use of the Intake Crib. When the north heading running shoreward had been carried about 250 ft. so much water was encountered that it was decided to discontinue the excavation work, concrete the shaft and part of the tunnel, build a bulkhead in the shaft and finish the remainder of the work from the Shaft No. 3. All necessary plant was located at Porter Ave. and in addition it would have been next to impossible to keep up communication between the Intake Crib and the shore during the winter season. Work at the crib was closed early in October, 1909, and the remaining work of placing the steel shaft casing, gates, winches, etc., was finished up in the summer of 1910.

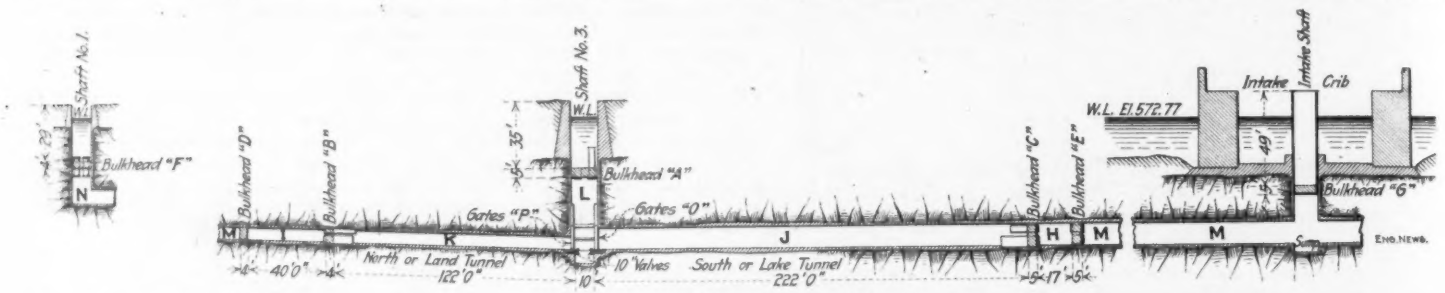


FIG. 15. SKETCH SHOWING BULKHEADS AND METHOD OF TAKING OFF COMPRESSED AIR AFTER COMPLETION OF TUNNEL; BUFFALO WATER-WORKS.

Taking Off Air.

As previously mentioned the tunnel was not designed to withstand any great outside pressure and it became quite a problem to take the compressed air off in such a manner as not to subject the concrete lining to any great outside water pressure before it was filled with water.

To further complicate matters there were four bulkheads to be removed, one each in the land and lake tunnels near Shaft No. 3 in which were the air locks, and one each in Shaft No. 1 and the Intake Shaft. The location of the bulkheads, etc., is shown on Fig. 15. The bulkheads remaining in, upon the completion of the tunnel are marked C, B, F and G. The first step was to build the bulkheads E in the Lake tunnel and D in the land tunnel after which bulkheads C and B were blown out and the air locks removed. The gates O and P in Shaft No. 3 were set and

the shaft concreted, after which the bulkhead A was built in the shaft. This bulkhead was of concrete 5 ft. thick and the form on which it rested was built of 3-in. planks resting on 12 × 12-in. timbers. The ends of the latter rested on another 12 × 12-in. timber supported in turn by 2-in. dowel pins let into holes in the shaft concrete. The timbers were wedged up about 1-in. from the pins, and when this bulkhead was ready to be blown out these wedges were slacked off, allowing the timber forms to drop about 2 ins. and thus breaking the force of the blasting.

Through this bulkhead was left a 4 × 5-ft. opening closed from the inside by a lock door and also a 16 × 2½-ft. man lock. The low-pressure air mains were carried down through this concrete and connected with two of the 10-in. valves running underneath the gates at the bottom of the shaft, giving a connection each way. From where the 10-in. pipes came up through the floor inside the gates low pressure air lines were run to bulkheads D and E through which pipes had been provided. This left a 10-in. pipe from each end under the second gates for drainage. One gate of each tunnel was then closed and caulked with oakum, and air from the entire battery of compressors was first turned into the land tunnel and drain pipes opened in the bottom of Bulkhead D. All pumps were started and the water was removed in about 4 hours. The high-pressure air lines from the power house to Shaft No. 3 had been removed to allow of other construction work on the new pumping station and all pumps were run by steam. When the shaft was closed off by the bulkhead the heat inside was intense. After the water was out of the land tunnel compressed air was put on the shaft (Section L), land tunnel section I and K and lake tunnel section J and H by closing the doors in bulkhead A. Then it was that the heat in the shaft really reached a terrific pitch. It was at times 135° above zero and in going down through the shaft lock the heat struck one in the face and a person could breathe only with the greatest difficulty. It was somewhat cooler at the bottom of the shaft and no one ever remained on the stage at the bottom of the lock any longer than necessary to get on to the ladder and get down.

To this haste in getting away from the awful heat was due one of the two fatal accidents on the work and one which came near causing other loss of life and damage. The second gate of the land tunnel had been jacked down and was being calked. Instructions were always to have at least two men inside the tunnel but one evening at 8 p. m. while the shift was out to lunch the pump man came up to get oil, leaving only the lock tender inside. The latter had, it seemed, hurried down off the platform after taking the lock in and fell to the bottom of the shaft where he was killed or drowned in the sump. It was then impossible to get down at Shaft No. 3 and as the gates were down it would do no good to get down at Shaft No. 1. After trying for two hours to raise the lock tender it was decided to go down through Shaft No. 1, put a cap on the 10-in. pipe running under the gate, shut the air off the tunnel and blow the air out of Shaft No. 3 and get in that way. It was found that the outside lock door at No. 1 had been tied up and the inner door leaked enough to take the lock in. It then became a question whether by opening all the blow pipes at Shaft No. 3 and slowing down the compressors it would be possible to reach the pumps before the water was over them. The combined blow pipes lowered the shaft pressure very slowly as the air came back with the water through the 10-in. drain pipe at the bottom of shaft No. 3. The door of the man lock was wedged out and pried open but there was still 20 lbs. of air in the tunnel and nearly as much in the shaft and it was impossible for a man to go through the 18 × 15-in. door of the man lock. One man had his clothes ripped from his back, a second was blown bodily into the air from 6 to 10 ft. but caught a brace. The force of the air blast was so strong that one man who did get inside the lock was nearly suffocated, the air going up his nose and distending his cheeks enormously and practically stopping his breath. He was hauled up with a rope. The next man was lowered head first with a rope around his legs or rather he forced himself down by taking hold of the ladder rounds and drawing himself down against the air. He reached the lower door of the lock and it shut quickly. When the pumps were reached we found the water about 1 ft. above the pump chamber floors. The lock tender was found a few minutes after in the sump.

After the north gates were calked the drain valve was closed and the air gradually withdrawn. The air was not entirely off this tunnel for two weeks after the air was shut off. Air was then blown off the shaft and the debris of bulkhead D and the piping were hoisted on top. In the lake tunnel there are two power cable and a telephone cable which are laid along the bottom to provide communication with the intake crib. These were lowered on reels and placed in the lake tunnel section J and the air put on tunnel section M and the water drained out. Then the shaft was closed and the air put on it after which bulkhead E was blown out and the cables laid and spliced and all pipe, etc., piled in the shaft, the south gates were closed and caulked and the air taken off the shaft. The next step was to remove bulkheads F in Shaft 1 and G in the intake shaft. This was done by opening the 10-in. drain valves at Shaft No. 3 and lowering the water level so that the bulkheads could be blown out. This was easily done as the forms on which they were built were strong enough to withstand the jar of the explosions. Finally the bulkhead A in Shaft 3 was blown out and the pumps removed. Shaft No. 3 then filled with water and the gates were raised. At the Intake a diver went down and brought up the ends of the three cables which had been left in the coils near the shaft.

Plant.

The main power plant at Porter Ave. was very complete in all respects and included five air compressors for high- and low-pressure service, electric lighting plant, eight boilers, etc. Three compressors with a combined capacity of 7,840 cu. ft. per minute supplied low pressure air for the tunnels while two compressors totaling 2,640 cu. ft. per minute supplied high-pressure air for the drills. These high-pressure machines carried 125 to 130 lbs. pressure at the receivers and the high pressure line was connected with the low pressure mains by means of a by-pass and reducing valve so that instead of blowing off at 130 lbs. pressure the surplus air escaped into the low pressure line. The capacity of the boiler plant was 1,025 H.P.

At Shaft No. 3 was located a separate boiler plant of 475 HP. to furnish steam (at 120 lbs. pressure) for running the pumps at the bottom of the shaft, for the cage hoist, for running an electric power plant for the electric railway system and for running the machine shop. There was also located here the machine shop, field office, drill repair shop, oil house, powder magazine, blacksmith shop, dry rooms for the men, store room, etc.

Throughout the work Ingersoll E 24 drills were used, with the bit gaging 2⅜ ins. on the starter down to 1⅜ ins. on the 10-ft. steel.

Early in 1909, a bonus system was inaugurated for the drillers, helpers and heading foremen and later on (in November, 1909) the system was extended to include everyone on the work and the result was very satisfactory.

Personnel.

The work was designed by and executed under the supervision of the Department of Public Works of the City of Buffalo, N. Y. Mr. Francis G. Ward is Commissioner of Public Works and Mr. Samuel J. Field was Engineer in charge of the work. The Buffalo Dredging Co. had the contract for all work on the shafts, tunnel and intake crib. Of that Company, Mr. S. J. Dark is Vice-President and Manager, and Mr. John Record, Chief Engineer. The writer of this article was General Superintendent throughout the work.

The Strength of Piers or Columns of Different Materials.

The diagram herewith shows the compressive strengths of columns or piers of various materials: steel, brick, cement mortar and timber. It brings clearly into view some comparisons well enough known in their fundamental figures but often forgotten. The fact that timber posts are stronger than either brick piers or cement (or concrete) columns appears plainly from the diagram. In a paper on "Fire Waste and Its Prevention," read before the National Association of Mutual Insurance Companies at Peoria, Ill., Sept. 28, 1910, Mr. J. E. Howard, of the Bureau of Standards, the author of this diagram, remarked on it as follows:

The comparative strength of steel columns is given at 30,000 lbs. per sq. in., an ordinary strength for structural steel. It may vary from this according to the grade of steel used, lower or higher according to the elastic limit of the metal, and modified by the workmanship.

The compressive strength of cast-iron columns has been found in the vicinity of 30,000 lbs. per sq. in. also. This metal occasionally gives higher results and at times lower. The uncertainty of having a sound casting is a source of trouble and detracts from the reliability of cast-iron.

The strength of individual brick greatly exceeds that of brick when laid in piers. This is due largely to the

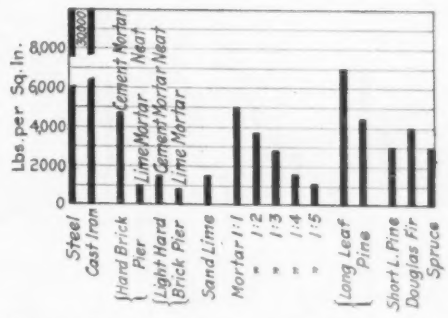


Diagram Showing Compressive Stength of Piers or Columns of Different Structural Materials.

grade of mortar employed. Hard-burned brick frequently range in strength from 15,000 to 20,000 lbs. per sq. in. when tested singly and an exceptional shale brick was found to possess the phenomenal strength of 38,000 lbs. per sq. in. In piers, however, one having a compressive strength of 3,000 lbs. is a very strong one, although when a hard brick is laid in neat cement a resistance between 4,000 and 5,000 lbs. may be displayed. The same grade of brick laid in lime mortar will develop only about 1,500 lbs. per sq. in. ultimate strength. Light-hard brick show less difference in strength whether laid in neat cement or in lime mortar. They develop lower strength than the harder brick, and being nearer the strength of the lime mortar the cushioning of the mortar is more favorable relatively. Provided the stronger brick could be laid in mortar having nearer the characteristics of the brick, then a much higher strength might reasonably be expected.

Sand-lime brick range in strength from 1,500 to 3,000 or 4,000 lbs. per sq. in.

The strength of mortar composed of Portland cement depends upon the richness of the mixture. The diagram illustrates the range which may be expected in mortars from a 1:1 mixture to a mixture containing one part Portland cement to five parts of sand. The rigidities of these mortars are approximately in proportion to their strengths. The strength of concretes is about the same as that of the cement mortars. The addition of the stone has been found not to modify the ultimate strength, over wide ranges. Some examples have shown a slight loss in strength of the concrete over that of the mortar used without the stone, and illustrations of the opposite kind may also be found.

Occasional sticks of long-leaf pine are found which develop the maximum strength plotted on the diagram, but a common strength is in the vicinity of 4,000 lbs. per sq. in., while 3,000 lbs. is an ordinary value for short-leaf pine. Douglas fir has generally a compressive strength of about 4,000 lbs. per sq. in.

These values are such as may be found, but the wide range in ultimate strength which is displayed by structural materials makes it necessary to consider specifically the properties of those materials which are actually to be used when judging of the strength of any particular structure.

Experimental Determination of the Rate of Heat Transmission in Surface Condensers.*

By GEORGE A. ORROK,† M. Am. Soc. M. E.

Ever since the first use of steam in the a[illegible], the condenser has been a very important part of the machinery designed for its utilization and the very simple laws governing condensation by mixture were early understood and formulated. With the advent of the surface condenser the problem became more complicated and the laws governing the transmission of heat through tubes or plates, from wet vapor or condensing steam to water, have been investigated by many physicists from Poisson in 1835, Peclet in 1841 and Joule in 1861 down to the present time.

The present status of the transmission of heat through metallic tubes from condensing steam to water according to various authorities may be stated as follows:

(a) The quantity of heat transmitted by a unit of surface in unit time is proportional to the temperature difference (Joule, Rankine and most of the experimenters) or to the square of the temperature difference (Werner, Grashof and Weiss) between the media on the different sides of the tube.

(b) The quantity of heat transmitted is proportional to some power of the water velocity ($\sqrt[3]{V_w}$ by Joule and Ser, $\sqrt{V_w}$ by Hagemann and Josse, V_w by Stanton).

(c) The quantity of heat transmitted is proportional to some power of the steam velocity or mass flow ($\sqrt{V_s}$ by Hausbrand and Ser, mass flow by Jordan.)

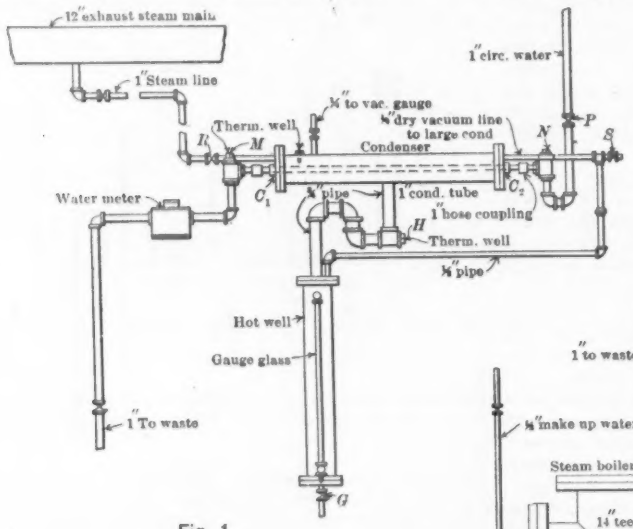


Fig. 1.

(d) The quantity of heat transmitted is greatly affected by the amount of non-condensible vapors on the steam side of the tube (Bourne, Smith, Weighton, Morrison, McBride).

These differences of opinion did not trouble designers seriously as long as small condensers and vacuums of over 2 lbs. absolute were the rule, but with the development of the turbine the need arose for condensers capable of condensing more than 200,000 lbs. of water per hour at an absolute pressure of less than 1 lb. At first, excessive amounts of surface were installed but the first cost and upkeep led to more careful design and the demand for a more accurate knowledge of the laws of heat transmission under condenser conditions.

Through the liberality of the management of the New York Edison Co., the author was enabled to develop the apparatus and make the experiments described below, the results of which confirm and complete much of the work of earlier experimenters. It is hoped that they will aid condenser designers in producing apparatus better suited to the work, more satisfactory and more economical than ever before.

Apparatus.

The object in making these tests was to determine the heat transfer through various kinds of condenser tubes and the laws governing its variation under different conditions of steam temperature, pressure and velocity; velocity of circulating water, and mean temperature difference.

In order to obtain these data, a small surface condenser was constructed with a relatively small cooling surface and it was operated under conditions as nearly like actual condenser conditions as possible. The steam inlet, dry vacuum, and circulating water lines were so arranged and controlled that any desired vacuum, any desired velocity of circulating water and any desired mean temperature difference could be maintained and that any one of these conditions could be varied through a considerable range quite independently of the other two. A hot well was constructed and so connected to the condenser that the temperature of the hot-well water (condensed steam) and its amount could be determined. Thermometers, pressure gages and a water meter were installed and a record was made of all desired data.

In order to fulfill the requirements, it was found necessary to make numerous changes in the apparatus as first constructed, which is shown in Fig. 1. As first constructed, it consisted of a condenser made of 5-in. extra-heavy wrought-steel pipe, with cast-iron blank flanges, drilled and tapped for the various steam, water and vacuum connections. The condenser was of such a length that exactly 1 sq. ft. of cooling surface on a 1-in. outside diameter condenser tube was included between the inside faces of its end flanges. A condenser tube was passed through the center of the condenser and projected about 4 ins. on each end through small stuffing boxes. A thermometer well and a vacuum gage connection were installed for recording the steam temperature and pressure. A hot well made of 5-in. wrought-iron pipe with a screwed and a blank flange on each end was connected to the condenser as shown. On the front of the hot well, a gage glass and a graduated scale were placed so that the height of the water could be observed and recorded, making it possible to calculate the weight of steam condensed for any given length of time. The valve *G* was used to empty the hot well at the end of a test. A thermometer was installed at *H* for observing the temperature of the condensed steam, the piping being so arranged that there was always a solid body of water surrounding the thermometer well. A ½-in. line connected the top of the hot well to the vacuum line to equalize the pressures. The entire condenser and ¾-in. line to the hot well were covered with 4 ins. of magnesia pipe covering to eliminate the effect of radiation.

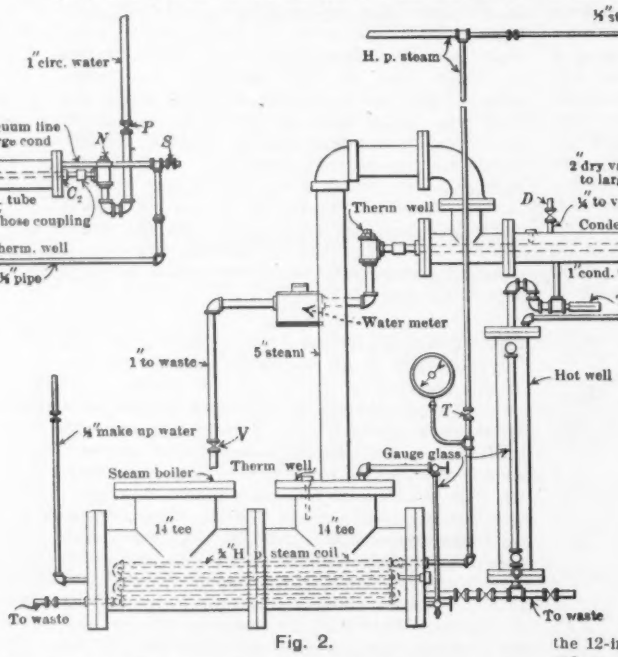


Fig. 2.

FIGS. 1 AND 2. APPARATUS FOR TESTS OF HEAT TRANSMISSION IN SURFACE CONDENSATION.

The 1-in. circulating water line was taken from a 6-in. salt-water fire line in which was maintained a pressure of 90 lbs. gage. This 1-in. line was connected to the condenser tube at each end by a piece of rubber hose which was wired at the ends to withstand a pressure of about 20 lbs. gage. Thermometer wells and thermometers were installed for observing the temperature of the circulating water at the inlet and the outlet of the condenser. A water meter was installed to register the amount of water flowing. The valve *P* was used to regulate the rate of flow.

The 1-in. steam pipe was taken from the bottom of a 12-in. exhaust main which carried the exhaust steam from various auxiliary engines to an open feed-water heater. The pressure in this line was about 2 lbs. gage. The valve *R* was used to regulate the amount of steam admitted to the condenser.

The ½-in. dry vacuum line was connected to the hot well of a large surface condenser which was operated at a vacuum of from 27.0 ins. to 28.5 ins. of mercury, or about 1 in. absolute pressure. All flanged joints were made up with ⅛-in. rubber gaskets and all screwed joints with a heavy coating of red lead on the threads. One of the greatest difficulties encountered when running tests at a high vacuum was the prevention of air leakage. This difficulty was overcome to a great extent by a frequent and liberal application of a special heavy asphaltic paint to all joints. It was found possible to hold a vacuum within 0.5 in. of mercury of that in the large condenser when all valves were closed, except valve *S* in the vacuum line. With *S* closed, this vacuum would drop only from 27 ins. to 26 ins. in a period of five minutes.

All thermometers used in these tests were of the best make and could be read with accuracy to 0.1° F. The water meter used was tested at various times and its error determined for all rates of flow. All heat transfer tests were extended over a period of ten minutes after conditions had become constant and readings of temperatures and pressures were taken every three minutes.

DIFFICULTIES.—A series of tests were made on various kinds of tubes at different vacuums, but it was found that the heat transfers calculated from these tests had a maximum variation of 20% for the same tube under exactly the same conditions as to steam temperature and pressure, mean temperature difference and velocity of circulating water. In these tests the vacuum was varied by regulating the steam admitted through the valve *R*, the vacuum line being kept wide open. It was found that to maintain a higher vacuum than 24 or 25 ins. of mercury the steam valve *R* could be opened only a very small amount and that the steam entering the condenser was superheated as much as 50° F. Another difficulty encountered was, that at low vacuum when the valve *R* was almost wide open, the heat transfer, figured from the amount of steam condensed as measured in the hot well, was considerably higher than that figured from the heat absorbed by the circulating water. This showed that the steam admitted must have contained considerable moisture. It was also found very difficult to maintain the rate of flow of the circulating water constant, due to the variation in pressure in the fire line from which it was taken.

To overcome these difficulties, a number of changes were made in the piping. A separator was installed in the steam line and the line was taken from the top of the 12-in. exhaust main instead of from the bottom. To aid in controlling the rate of flow of the circulating water, a pressure gage was installed in the line, and to maintain a constant rate of flow it was necessary only to keep this pressure gage indicating a steady pressure by regulating inlet valve *P*. In order to make it possible to maintain a high vacuum in the condenser without undue throttling of the steam, the dry vacuum line was increased in size to a 1-in. pipe.

Another series of tests was then made and it was found that the moisture in the steam at low vacuums was practically eliminated. It was also possible to maintain a high vacuum, although there still seemed to be a more or less uncontrollable degree of superheat and the heat transfers for these high vacuum tests were considerably lower than those at the lower vacuums. A water jacket was now placed on the steam line with a ½-in. water connection from the circulating water line. This arrangement seemed to have but slight effect, however, and there was still found to be a considerable variation in heat transfer when an attempt was made to duplicate tests.

IMPROVEMENTS.—It was decided that the difficulty must lie with one of the following things:

(a) The quality of the steam as to amount of superheat, moisture, or entrained air and oil.

(b) The circulation or velocity of the steam.

(c) Air leakage.

(d) Cleanliness of the tubes.

To take care of the first item, it was decided to build a small independent boiler and generate steam as it was needed by means of a high-pressure steam coil. The boiler was constructed of two 14-in. flanged tees bolted together, with blank flanges bolted on the ends. It was connected to the condenser by a 5-in. pipe, the condenser being reduced in length and a 5-in. flanged tee bolted on one end, making the total face-to-face dimension the same as before. A steam coil, consisting of ap-

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TABLE I.—VALUES OF U, S AND θ FOR VARIOUS ASSUMED VALUES OF N.

S = cooling surface in sq. ft.
$N = U\theta_m$ = total heat transfer per sq. ft. per hr. in B.t.u.
U = heat transfer per sq. ft. per hr. per deg. m.t.d.
θ_m = m.t.d. = mean temperature difference
Q = circulating water per hr. in lbs.
K = a constant determined by experiment
t_s = temperature of steam
t_0 = temperature of circulating water at inlet
t_1 = temperature of circulating water at outlet
t = any temperature between t_0 and t_1

	N =	U =	S =	θ_m =
1	K	$\frac{K}{\theta}$	$\frac{Q}{K}\left[(t_s - t_0) - (t_s - t_1)\right]$	$t_s - \frac{t_1 + t_0}{2}$
2	$K\theta$	K	$\frac{Q}{U}\operatorname{Log}_e \frac{t_s - t_0}{t_s - t}$	$\frac{t_1 - t_0}{\operatorname{Log}_e \frac{t_s - t_0}{t_s - t_1}}$
3	$K\theta^2$	$K\theta$	$\frac{Q}{K}\left[\frac{1}{t_s - t} - \frac{1}{t_s - t_0}\right]$	$\sqrt{(t_s - t_0)(t_s - t_1)}$
4	$K\theta^{\frac{1}{2}}$	$\frac{K}{\theta^{\frac{1}{2}}}$	$\frac{2Q}{K}\left[(t_s - t_0)^{\frac{1}{2}} - (t_s - t)^{\frac{1}{2}}\right]$	$\left[\frac{\frac{1}{2}(t_1 - t_0)}{(t_s - t_0)^{\frac{1}{2}} - (t_s - t_1)^{\frac{1}{2}}}\right]^2$
5	$K\theta^{\frac{1}{4}}$	$\frac{K}{\theta^{\frac{1}{4}}}$	$\frac{8Q}{K}\left[(t_s - t_0)^{\frac{1}{4}} - (t_s - t)^{\frac{1}{4}}\right]$	$\left[\frac{(t_1 - t_0)^{\frac{1}{4}}}{(t_s - t_0)^{\frac{1}{4}} - (t_s - t_1)^{\frac{1}{4}}}\right]^4$
6	$\frac{K}{\theta^{n-1}}$	$\frac{K}{\theta^n}$	$\frac{Q}{Kn}\left[(t_s - t_0)^n - (t_s - t)^n\right]$	$\left[\frac{n(t_1 - t_0)}{(t_s - t_0)^n - (t_s - t_1)^n}\right]^{\frac{1}{1-n}}$

NOTE:—No. 1 has been heretofore generally used; No. 3 is used in European practice; No. 5 is the one determined by the author's experiments; No. 6 is the general form.

proximately 22 ft. of ¾-in. wrought-steel pipe, was placed in the boiler in such a way that it was entirely below the water level and still left a sufficient disengaging surface for the steam. Steam was supplied to this coil from a high-pressure steam main through a 1-in. pipe. Make-up water for the boiler was taken from a Croton water line through a ½-in. pipe. The bottom of the hot well was also connected to the boiler by a ¾-in. line containing a gate and a check valve so that the condensed steam could be returned directly by gravity to the boiler. This arrangement obviated the necessity of breaking the vacuum and emptying the hot well after each test. A gage glass and a thermometer were installed. The whole apparatus as reconstructed is shown in Fig. 2.

To take care of the second item, the vacuum line was increased to 2 ins. A ¼-in. connection for a vacuum gage was installed at E and a ¾-in. valve opening to atmosphere at F. With this arrangement, for any desired opening of the valve S, a constant velocity of steam through the condenser could be maintained by regulating the air valve F and the valve K, so that the steam passing through the valve S had a constant drop in pressure. This drop, due to velocity of the steam, was considered to be the difference in pressure as read at E and D.

The subject of air leakage was investigated by closing all valves except S and K in the vacuum line, when it was found possible to hold a vacuum in the condenser practically equal to that in the large condenser. The valve S was then closed and observations were taken as to the rate of fall of the vacuum in the apparatus. It was found that the vacuum would drop only from 28 ins. to 27 ins. of mercury in 15 minutes. These air-leakage observations were taken before each series of tests.

In order that the condition of the tubes as to cleanliness should not affect the heat temperature, all tubes used for testing were thoroughly cleaned after every ten or twelve tests. A series of tests made with this remodeled apparatus under constant conditions was found to have a maximum variation of not over 10% and an average variation of 3 or 4%. In these tests, the vacuum was varied by regulating the amount of steam admitted to the steam coil through the valve T.

Methods.

Tests were run at vacuums of 7, 15, 20, 25 and 27 ins. of mercury, with circulating water at a temperature of about 40° F. and a velocity of 8.6 ft. per sec. on 16 different tubes. The tests with a glass tube were difficult to make on account of the thinness and fragility of the tube and the tube was broken before all the desired tests were completed. In all these tests, it was found that the temperature of the steam was constant throughout the apparatus.

A series of tests was made on an Admiralty tube with a range in velocity of circulating water of from 1 to 11 ft. per sec. and vacuums of 15 and 27 ins. of mercury. In these tests the velocity of the circulating water was varied by regulating the valves at P and V, the pressure in the condenser tube being always kept above 10 lbs. gage. All the above tests were made without changing the temperature of the circulating water, which was about 40° F.

To vary this temperature, a ½-in. line was installed connecting the high-pressure steam line to the circulating water line as shown in Fig. 2. With this arrangement, it was possible to vary the temperature of the circulating water from 40 to 110° F., thus varying the mean temperature difference without altering the other test conditions, and a series of tests was made on an Admiralty tube to determine the variation of heat transfer with changes of mean temperature difference.

Finally, a series of tests was made on all the various kinds of tubes with circulating water at a temperature of 85° F. and velocity of 8.7 ft. per sec. and a vacuum of 27 ins. of mercury.

Variation of Heat Transfer with Temperature Difference.

After the apparatus had been working some time and had been giving consistent results, a set of approximately 100 tests was run to determine the possible varation of the heat transmission with the mean temperature difference. The quantities of cooling water were so large that the temperature rise $(t_1 - t_0)$ was always small and it was considered that the arithmetical mean of the water temperatures and the steam temperature might be used without appreciable error in the calculation of the heat transfer. These tests were run at four different velocities, approximately 2, 4, 6 and 8 ft. per sec., the results were plotted on logarithmic paper and a smooth curve drawn through each set of plotted points. These curves were practically straight lines, as shown in Fig. 3, with a slope of about 0.125.

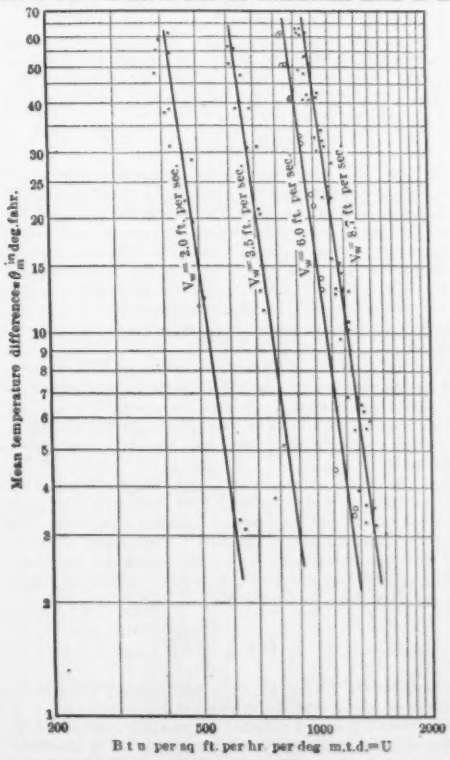

Mean temperature differences θ_m in deg. fahr.
B t u per sq ft. per hr. per deg m.t.d.=U
V_w = 2.0 ft. per sec.
V_w = 3.5 ft. per sec.
V_w = 6.0 ft. per sec.
V_w = 8.7 ft. per sec.

Fig. 3. Observed Results as Plotted on Logarithmic Paper to Determine Equation Between Rate of Heat Transfer and Temperature Difference.

The relation for any given point in a long condenser tube may then be stated, $U = \frac{C}{\theta^{\frac{1}{8}}}$. In which θ is the temperature difference of the steam and cooling water at the given point. [See Table I. for list of symbols. —Ed.] Working from this, an expression may be obtained for the relation between the condensing surface or length of tube (S) and the temperature rise of the condensing water $(t_1 - t_0)$.

$$S = C_1\left[(t_s - t_0)^{\frac{1}{8}} - (t_s - t_1)^{\frac{1}{8}}\right]*$$

and the true mean temperature difference is

$$\theta_m = \left[\frac{\frac{1}{8}(t_1 - t_0)}{(t_s - t_0)^{\frac{1}{8}} - (t_s - t_1)^{\frac{1}{8}}}\right]^8$$

an expression which, in all practical cases, differs very slightly in numerical value from the geometrical mean†

$$\theta_m = \frac{(t_1 - t_0)}{\log_e \frac{t_s - t_0}{t_s - t_1}}$$

The general expression connecting U and θ is $U = \frac{K}{\theta^n}$, where n may have any positive or negative value excluding 0. The general expression connecting S and $(t_1 - t_0)$ will be

$$S = \frac{C_1}{n}\left[(t_s - t_0)^n - (t_s - t_1)^n\right]$$

and the true mean temperature difference is

$$\theta_m = \left[\frac{n(t_1 - t_0)}{(t_s - t_0)^n - (t_s - t_1)^n}\right]^{\frac{1}{1-n}}$$

For the case where $n = 0$ or $U = K$, a constant,

$$S = C \log_e \frac{t_s - t_0}{t - t_1}$$

$$\text{and } \theta_n = \frac{t_1 - t_0}{\log_e \frac{t_s - t_0}{t_s - t_1}}$$

In Table I. are tabulated values for U, S, θ_m and N (the total quantity of heat transferred) corresponding to various values of the exponent n in the equation $U = \frac{K}{\theta^n}$. The curves of temperature rise and values θ_m are plotted in Fig. 4 for certain steam and water temperatures.

Only two investigators, so far as I have been able to determine, have attempted experimentally to verify the law of the rise of temperature of condensing water in its passage through the condensing tube.

J. Alex. Smith‡ experimented with a tube 6 ft. long, and Professor Josse‖ used a surface condenser of approximately 86 sq. m. surface. Neither experimenter gives his actual numbers but shows his results in a curve.

*This equation is derived as follows:—Ed.

$$Q\delta t = U \cdot \delta s \cdot (t_s - t)$$

$$= \frac{C}{\theta^{\frac{1}{8}}} \cdot (t_s - t)\,\delta s$$

$$= \frac{C}{(t_s - t)^{\frac{1}{8}}} \cdot (t_s - t)\,\delta s$$

$$\frac{\delta t}{\delta s} = \frac{C}{Q} \cdot (t_s - t)^{\frac{7}{8}}; \quad \frac{\frac{\delta t}{\delta s}}{(t_s - t)^{\frac{7}{8}}} = \frac{C}{Q}$$

$$\text{Integrating, } -8(t_s - t)^{\frac{1}{8}} = \frac{C}{Q}s + K_o$$

Now evalnate between limits $s = o$ and $s = S$
When $s = o$, $t = t_o$, and $K_o = -8(t_s - t_o)^{\frac{1}{8}}$
When $s = S$, $t = t_1$

$$\text{and } -8\left(t_s - t_1\right)^{\frac{1}{8}} = \frac{C}{Q}S - 8\left(t_s - t_0\right)^{\frac{1}{8}}$$

$$\text{Transposing, } S = \frac{8Q}{C}\left[\left(t_s - t_0\right)^{\frac{1}{8}} - \left(t_s - t_1\right)^{\frac{1}{8}}\right]$$

†Obtained by assuming a constant mean rate of heat transmission from end to end of the tube.
‡London "Engineering," March 23, 1906.
‖"Zeitschrift" des Vereines Deutscher Ingenieure, Feb. 27, 1909.

Smith gives a second curve showing the deviation of his experimental numbers from the geometrical series which best represents his results. It is unfortunate that further accurate experiments have not been made on this particular phase of the subject, but none of these results are inconsistent with the conclusions arrived at from the author's experiments. In fact, the variations between the geometrical curve found by Josse and Smith and the writer's experiments are smaller than the variations of the actual points and the theoretical points in Smith's curves.

Variation of Heat Transfer with Velocity of Water.

A series of practically 100 tests was run to determine the variation of heat transferred with the velocity of the circulating water. These tests were run at various velocities from 1 to 11 ft. per sec. and the results are plotted in Fig. 5. These tests were run at two different vacuums, 15 ins. and 27 ins. approximately, and the figure shows how closely the heat transmission varies with the square root of the water velocity. The third curve in Fig. 5 is a curve of total heat transmitted and apparently varies according to the same law.

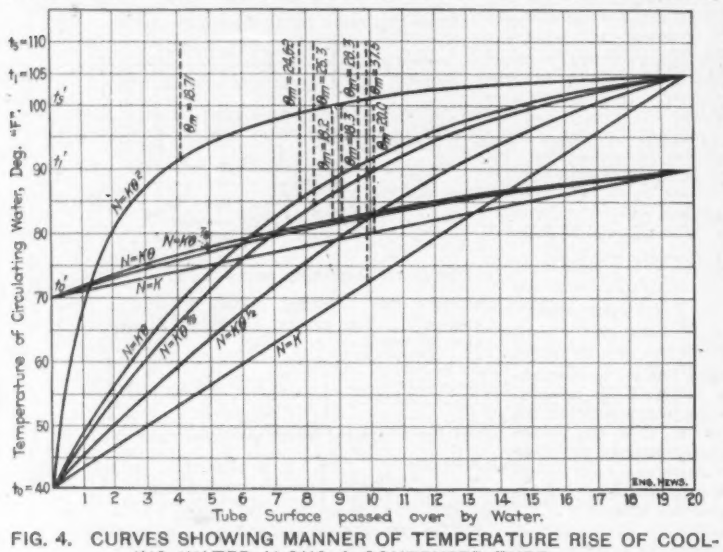


FIG. 4. CURVES SHOWING MANNER OF TEMPERATURE RISE OF COOLING WATER ALONG A CONDENSER TUBE.
(Each curve corresponds to the asumption of the relations indicated between heat transmission and temperature difference.)

Variation of Heat Transfer with Velocity of Steam.

That the velocity of the steam across the tube surface has an effect on the transmission has been asserted by a number of authorities. Hausbrand and Ser have considered that the heat transmission was proportional to the square root of the steam speed. Jordan maintains that the transmission is proportional to the mass flow of the steam. Most of the other investigators have neglected this. In the experiments, we have been unable to detect any effect on the heat transmission which might be charged to the velocity of the steam approaching the tube surface.

Let us consider a condenser consisting of a single tube, through which the cooling water is flowing, surrounded by an atmosphere of steam. Condensation will take place at the outer surface of the tube and the steam will rush in toward the tube from all sides. Meanwhile, the space surrounding the tube will attain a constant pressure due to the regular influx of steam into the condenser and its condensation on the tube. This constant pressure will determine the temperature of the steam and if there is no air leakage the temperature will be that due to the saturated vapor of water at the constant pressure. It has been determined experimentally that the temperature and pressure remain sensibly constant throughout the condenser, except for an exceedingly minute space in the neighborhood of the tube surface.

There is then a constant flow normal to the surface of the tube besides such residual velocity as may be in the steam after its passage through the exhaust pipe. This residual velocity in practice is usually from 200 to 600 ft. per sec. and in turbine installations may be as high as 800 ft. per sec. In direction, it follows the axis of the eduction nozzle until deflected by the tubes, sides of the condenser or baffle plates and constantly loses velocity until, at the further end of the steam travel, this velocity is entirely lost. The component of this residual velocity longitudinally to the tube is of no value in bringing a particle of steam to the condensing surface; neither is the component of this velocity normal to the tube surface, for its action is balanced by carrying away the steam on the opposite side of the tube. Its only action then is to distribute the steam among the tubes.

When a particle of steam comes in contact with the surface of the tube, it is immediately condensed and contracts enormously in volume. At atmospheric pressure the volume of water is approximately $\frac{1}{1,600}$ of the steam volume. At 28 ins. of vacuum, or 1 lb. abs., the contraction is about $\frac{1}{21,500}$, and at 29.5 ins., or ¼-lb. abs., 77,000 cu. ft. of steam condenses to 1 cu. ft. of water. The vacuum thus created induces a flow of steam normal to the tube surface, the velocity of which, neglecting friction, can easily be calculated for various conditions by means of the formula $V = \sqrt{2gh}$. Transforming this formula we get $V = 96.25\sqrt{(P_t - P_a)\,\sigma}$, where P_t = vacuum pressure (lb. abs.), P_a = partial pressure due to air in the condenser, and σ = specific volume of steam at pressure $(P_t - P_a)$.

The velocity with which the steam particles strike the tube surface is apparently independent of the distance they travel before striking, and is reasonably independent of the vacuum. The velocity varies from about 1,750 ft. per sec. at 1 lb. abs. to about 1,900 ft. per sec. at 14.7 lbs. abs. or atmosphere. These values of V have been computed, and the effect of a small quantity of air in the condenser on the velocity of flow of the steam was shown to be very small.

The Effect of Air Upon Heat Transmission.

During the early portion of these tests it was impossible even to approximate air-free steam, so that consistent transfer results could not be obtained. With the changing of the apparatus to a closed cycle, it was possible to keep the air down to a rather small quantity, and the results obtained were much more consistent. It is probable in these cases that the partial air pressure never exceeded 1½-in. and in most cases was below this point. By reason of close attention to all possible sources of air leaks in the final tests run it is probable that the partial air pressure never exceeded ¼-in. and was sometimes much less than this.

The best experiments on the effect of air that I have been able to find were described by James Alexander Smith in a paper read before the Victorian Institute of Engineers on December 6, 1905, which was reprinted in London "Engineering," March 23, 1906. His results show that a partial pressure of air amounting to 1/10-in. will reduce the heat transmission 25%; ¼-in. of air will reduce it 40%; and ⅝-in. partial air pressure will reduce the heat transfer about 50%. It is much to be regretted that Mr. Smith did not give his numbers, but the curves are sufficiently clear for use.

Conclusions.

(a) The heat transferred from condensing steam surrounding a metallic tube to cold water flowing through the tube is proportional to the seven-eighths power of the mean temperature difference of the water and steam temperatures. This is equivalent to the statement that the coefficient of heat transfer, U, is inversely proportional to the eighth root of the mean temperature difference.

(b) The coefficient of heat transmission, U, is approximately proportional to the square root of the velocity of the cooling water.

(c) The coefficient U is independent of the vacuum and of the velocity of the steam among the tubes or in the condenser passages. It may be proportional to the square root of the velocity normal to the tubes, but in all common cases this velocity does not vary more than a tenth part.

(d) The effect of air on the heat transferred is very marked indeed, particularly at high vacuums, and most of this air is due to leakage through the walls and joints of the apparatus. Working from Smith's curves and certain picked tests, where the volume of air could be calculated, the effect of the presence of air in reducing the value of U is as follows:

$$U = c\left(\frac{P_s}{P_t}\right)^{\frac{1}{8}}$$

where P_s is the partial pressure due to the steam and P_t is the total steam and air pressure.

(e) Taking the heat transfer of the copper tube as 1.00, under similar conditions the transfer for other materials is approximately as follows: copper, 1.00; Admiralty, 0.98; aluminum lined, 0.97; Admiralty oxidized (black), 0.92; aluminum bronze, 0.87; cupro-nickel, 0.80; tin, 0.79; Admiralty lead-lined, 0.79; zinc, 0.75; Monel metal, 0.74; Shelby steel, 0.63; old Admiralty (badly corroded), 0.[illegible]; Admiralty vulcanized inside, 0.47; glass, 0.25; Admiralty vulcanized both sides, 0.17. This coefficient (due to the material of the tube) will be designated by μ. Corrosion, oxidation, vulcanizing, pitting, etc., have also a marked effect in reducing the transfer. This reduction, as shown by the Admiralty tube which gave $\mu = 0.55$, may reduce the transfer at least 50%.

(f) The foregoing conclusions may be expressed mathematically as follows:

$$U = K\,\frac{C\,\rho^{\frac{1}{8}}\,\mu\sqrt{V_w}}{\theta_m^{\frac{7}{8}}}$$

where C = the cleanliness coefficient varying from 1.00 to 0.5,
μ = the material coefficient varying from 1.00 to 0.17,
ρ = the steam richness ratio, $\frac{P_s}{P_t}$ varying from 1.00 to 0,
V_w = the water velocity in ft. per sec.,
θ_m = the mean temperature difference,
K = a constant, probably about 630.

The effect of the length of tube, or rather length of water travel, has not been considered and the design of the condenser must be such that there is a free steam passage to every tube.

(g) This expression for U is cumbersome to use and for modern turbine condenser work certain conditions may be taken as well settled. The guaranteed vacuum is usually 28 ins. The entrance circulating water is usually 70° and a 20° temperature rise is considered economical. Under these conditions $\theta_m = 18.3$ and $\theta_m^{\frac{1}{8}} = 1.44$. θ_m calculated on the geometrical curve is 18.2. For these cases it will be nearly as accurate and much simpler to calculate θ_m by the logarithmic method, neglecting θ in the denominator and using 435 or $\frac{630}{1.44}$ for K_1. The expression will then be $U = K_1\,C\,\rho^{\frac{1}{8}}\,\mu\sqrt{V_w}$.

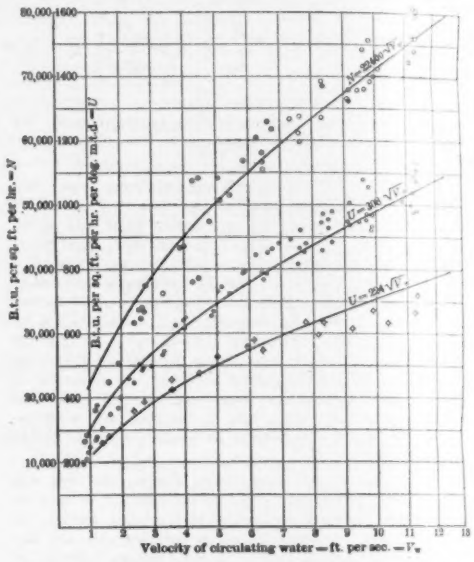


Fig. 5. Variation of Heat Transmission With Water Velocity.
(Plotted from observed results.)

(h) The above equation agrees well with the results of a number of tests on full size condensers under varying conditions. There appears to have been no attempt to determine the amount of air handled by the air pump in these cases, but the amounts of air indicated by the formula are such as agree with the pressures and temperature taken. The measurement of the dry pump discharge has been undertaken and the author hopes to have more information on this point in the future.

A GOOD-ROADS EDUCATIONAL TRAIN is to be run over the lines of the Pennsylvania R. R. starting at Harrisburg Jan. 25. The roads train will be in charge of the Pennsylvania State College cooperating with the Roads Department of the National Government and the State Highway Department of Pennsylvania. The train, consisting of four cars, will be used for lecture purposes in villages and small towns along the lines of the Pennsylvania Railroad. One car will be fitted up with a lantern for the illustrations of the lectures. Another car will be used for exhibits showing models of several types of roads such as earth, sand-clay, gravel, macadam and telford. This car will also contain a series of photographs and drawings illustrating the different methods of drainage and kinds of construction required for special conditions. Two flat cars will contain samples of the most important machinery required for road building also a home-made roller, drag, and sprinkling wagon.

Concrete Pile Foundations in Drilled Holes.

A job of underpinning required by unusual conditions and carried out by a novel scheme has recently been completed in the new terminal of the New York Central & Hudson River Railroad at New York City.

Near the northerly end of the yard, 54th St. crosses the yard on a concrete-floor bridge, carried by steel girders resting on columns set outside of the central tracks. The columns supporting the easterly end of this bridge have shown a settlement, due to a compression or a movement of the soft material which occurred in a pocket of the rock at this point. The remaining columns of the street superstructure nearby have their footings directly on rock, but under the group of four columns just at the bridge the rock dips to 15 to 20 ft. below the track level, and at this point the settlement has occurred, in spite of the fact that the concrete footing was constructed about 4 ft. deep here.

It was therefore decided to provide a more secure foundation by underpinning the present columns without removing them, and carrying the foundations to rock, after which the original level would be restored by jacking up the columns. On account of close proximity of the main line tracks to the columns, any excavation would have interfered very seriously with the traffic on the adjacent tracks, and due to the danger to traffic, it was decided it was not feasible to cut or blast out the concrete footing wall or the protection pier which extends above the foundation footing about 6 ft. The engineers in charge, therefore, decided to put holes down to rock and to cast concrete piles in these holes. Through former operations, there has been a considerable amount of core drilling in the terminal reconstruction, and machines were at hand capable of drilling 14-in. holes, the size considered desirable at this point.

In using these machines the plan was to drill down four holes close together around each column, driven through the concrete footing to rock and penetrating into the rock far enough to make sure a sound bottom had been reached, then to cast reinforced-concrete piles in these holes, place an I-beam grillage on top of the four-pile group and rest the column on this new base.

The work was carried out without incident or extreme difficulty, except the interruption and slow progress occasioned by the drilling through reinforcing rails embedded in the concrete, timber grillages and boulders in the soft material below. The drills were set up on the street above (see view Fig. 1) and worked through holes cut in the street floor. The first operation was to drill a 14-in. hole down through the concrete footing. Through this a 10-in. extra heavy steel pipe was driven through the soft material to rock. The hole was afterwards cleaned out and a 5-in. core hole was put down into the rock from 4 to 8 ft. in order to ascertain if bed rock and not boulder had been struck. In case the drill passed through the rock into the soft material, showing that a boulder had been struck, the steel pipe, whose lower end was fitted with a thick cast-steel drive shoe, was driven down through the obstruction by a heavy ram. When a final bearing on rock had been secured, reinforcement consisting of seven 1-in. longitudinal rods with ¼-in. wire wrapping, previously made up on the ground to the length required, was lowered into the hole and the hole then filled with a 1:2:4 mixture of concrete, carefully tamped or churned into place.

FIG. 1. STREET-BRIDGE OVER GRAND CENTRAL TERMINAL YARD AT 54TH ST. AND PARK AVE., NEW YORK CITY; DRILLING 14-IN. HOLES FOR CONCRETE UNDERPINNING PILES.

The four piles of the set were spaced 3 ft. longitudinally, 2 ft. 8 ins. transversely, or as close as the column base permitted. The entire work included only 16 holes, but, due to its nature, required about two months to complete, with two machines at work during part of the time. The drills, one a Davis the other a Terry (both shot drills), had no difficulty in cutting through the concrete and the reinforcing rails of the foundation. Most of the delay in the work was caused by striking boulders in the soft material and timbers.

The sketch Fig. 2 herewith illustrates the arrangement of piles, foundation and the structure supported.

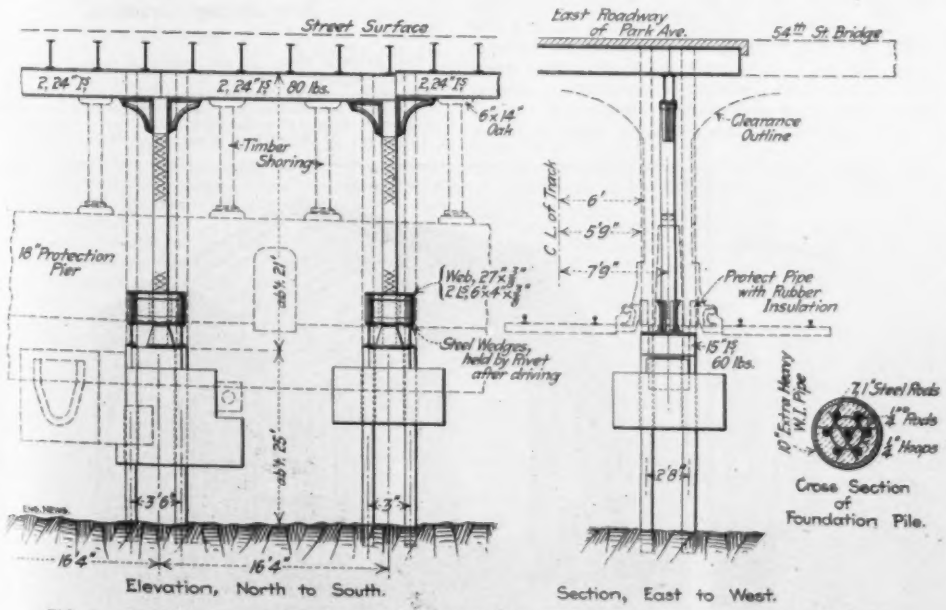


FIG. 2. SKETCH OF STREET BRIDGE COLUMNS AT 54TH ST. AND PARK AVE., SHOWING NEW FOUNDATIONS.

A TICKET-MAKING MACHINE has recently been installed by the Long Island R. R. Co. at its Flatbush Ave. station in Brooklyn, N. Y. The machine was manufactured in France, where a number are said to be in service, and is the first one of its kind to be used in America. By its use the ticket agent can in a few seconds make a ticket between the issuing station and any other point on the division. Besides the two stations the ticket also has the date of issue, the purchase price, and a number, dependent upon the class and destination. Four classes of tickets may be issued, whole-fare one way or excursion and half-fare one way or excursion. Besides the ticket the machine also prints two paper record slips for the use of the auditing department and acts as a cash register by recording the total sales. The stations and kind of tickets are indicated on dials on top of the machine. These are set by the operator, who pushes a lever which brings the plates into position, a small electric motor then completes the operation. It is said that the machine is so satisfactory that others will be installed.

Three French Military Balloon Sheds.

The French government authorities, being strongly impressed with the value of balloons and aeroplanes for military use, are displaying much activity in providing and trying airship equipment. Both army and navy are at work in this field. Depots or landing stations and flying grounds are being developed at numerous points; the navy is establishing a depot in connection with its extensive naval facilities at the port of Toulon, and the army has already fitted out a number of stations.

Balloon sheds are the most formidable structures required in such stations. From the standpoint of the designer of structural steelwork they represent quite special problems of design, and both in France and in Germany steel constructors have worked at the problem with much interest and ingenuity. The views herewith picture three French army sheds recently built, which illustrate how the problem is being handled.

The shed with cylindrical roof shown in Fig. 1 is at the aeronautic grounds at Lamotte-Breuil. This house is approximately 70 ft. by 400 ft. in ground plan, and 80 to 90 ft. high. The transverse bents of columns and semi-circular roof-trusses are largely relieved of side forces by two tiers of guy-ropes fixed to ground anchors set 25 to 30 ft. from the side of the building. Both ends of the building are fitted with double doors, the doors occupying the full width and height of the gable end.

A prior cylindrical-roof shed was built at the maneuvering grounds at Issy-les-Moulineaux, and this indeed served as model for the Lamotte-Breuil shed. The Issy shed (shown completed at the right in Fig. 2, and in Fig. 3 as it appeared during erection) is 393 ft. by 66 ft., and 85 ft. high in the clear. The arrangement of the guy-ropes is clearly apparent in Fig. 2; its purpose is to reduce the weight and cost of the framework by taking up the larger part of the lateral wind pressure. The form of arch bent employed in the framing and the arrangement of girts and bracing may be seen in Fig. 3. The covering of roof and sides is corrugated iron; lining of cork composition is provided for warmth. There is a gangway along the roof, for inspection of the structure. In the interior there are galleries about 50 ft. above ground for access to the upper parts of the balloon.

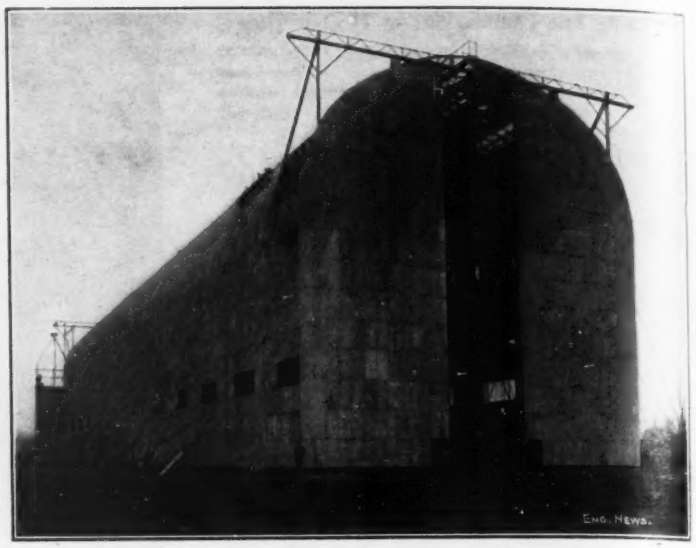


FIG. 1. BALLOON SHED AT LAMOTTE-BREUIL, FRANCE.

The Issy shed has doors at one end only, the other end being a fixed wall. The door occupies the entire end, so that each leaf is about 40 by 66 ft. The leaves slide on a track rail at the bottom and a guide-track frame at the top (supported and braced by the framework of the building). By the use of ball bearings the motion is made very easy, and while cable-winch power is provided for opening and closing the doors they are usually opened simply by pushing the doors along the track by hand. The doors consist of steel framing covered with corrugated iron; each leaf weighs 16 tons.

Fig. 3 shows also the traveling erection tower used in erecting this shed. The side steelwork was set by small derrick frames, the tower doing the arch work. The whole shed frame was erected in the short time of 10 days.

While the arched-roof shed is thought best for housing single dirigibles, flat-roof sheds are built for taking two smaller balloons side by side, and such a shed has been constructed at Issy alongside the other, as Fig. 2 shows. This shed is 129 ft. by 328 ft., and is 91 ft. high to the ridge. It will accommodate two airships of 56 ft. diameter. The back of the shed has a fixed wall, while the front end is open except for two low doors or gates, hinged to swing out. The shed being thus always open to the weather, no insulating lining is used, the sides being plain corrugated iron.

Fig. 4 shows the framing, and exhibits the three-hinged arch roof construction. The arrangement of trussed purlins, secondary columns and jack-rafters and shape-steel purlins is well adapted to secure economy of weight. The main trusses are spaced about 40 ft. The erection was carried out by the same machinery as employed for the other shed.

The three sheds shown were built by G. Sohier, 121 Rue Lafayette, Paris, from whom the data and the views were obtained through the interest of Mr. F. M. Weldon, of 136 Rue d'Assas, Paris, France.

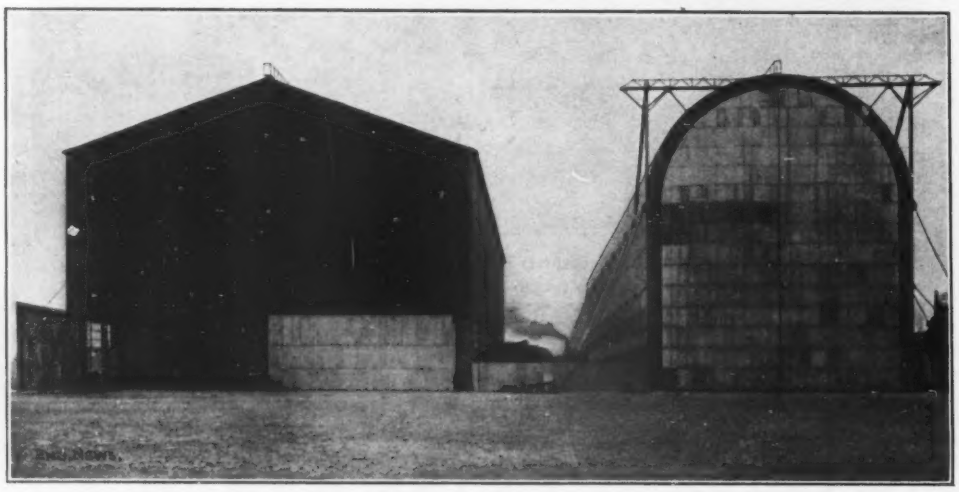


FIG. 2. GROUP OF TWO BALLOON SHEDS AT THE ISSY GROUNDS, NEAR PARIS, FRANCE.

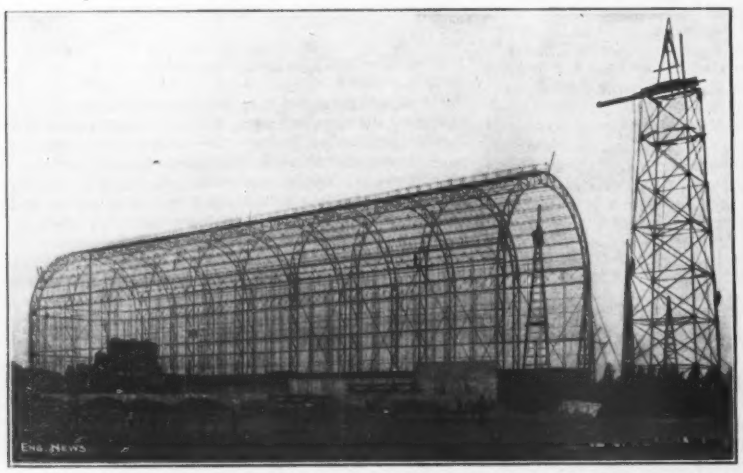
Meadow Roads as Constructed in Southern New Jersey Counties.*

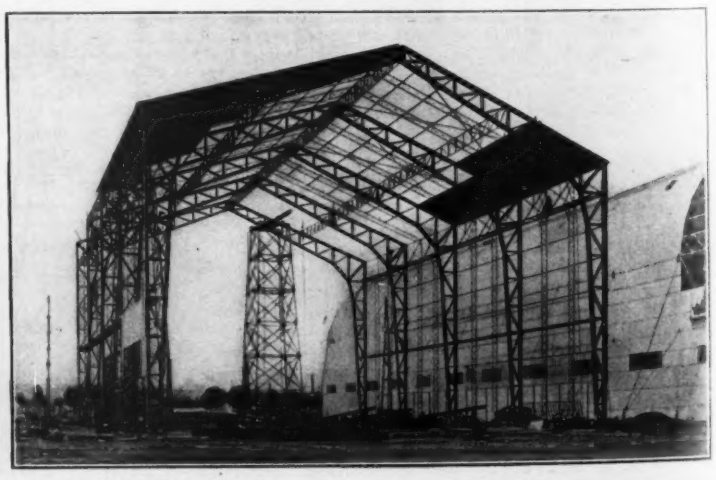
By E. D. RIGHTMIRE.†

The Atlantic Coast of the southern part of the state of New Jersey is fringed with a line of low barrier

*A paper read before the New Jersey State Association of County Engineers, January, 1911.

†Engineer of Atlantic County and of Atlantic City, N. J.





FIGS. 3-4. THE ISSY SHEDS UNDER CONSTRUCTION.

beaches consisting in their original state of sand dunes. On these beaches are situated many summer resorts, which have rapidly grown in favor and population. Separating these beaches from the mainland is an expanse of "meadow," varying in width from two to six miles, which is interspersed with numerous "lagoons" or "bays" which are connected with each other and the ocean by tidal channels known as "thoroughfares."

The meadows are composed of a crust, usually from 2 to 4 ft. in thickness, formed by the interlacing of roots and decayed vegetable matter, with grass growing on its surface. The surface of the meadow is slightly above the level of ordinary high tide, and the entire crust is underlaid with a mass of mud in a semi-liquid condition, which, in turn, is underlaid with sand, gravel and clay at depths varying from zero to 30 ft. or even more.

In times of easterly or northeasterly storms, the water from the ocean is forced by the wind through the inlets between the barrier beaches, and when combined with the tide reaches a maximum elevation of about 4 ft. above the meadow surface at high water.

It can be readily seen that the construction of roads across this meadow at sufficient elevation to maintain travel during these storm tides will be both difficult and expensive. The first roads built were of corduroy construction, covered with gravel or oyster shells, depending upon the floatage of the sod construction of the underlying mud for the maintenance of their elevation. Under heavy loads these roads were sometimes depressed below the level of the surrounding meadow and as additional weight of materials was deposited on them to maintain their elevation they naturally became still more depressed, requiring continual maintenance to keep them above the elevation of high tide. As the surface of the roads was only a few inches above the meadow, they were frequently inundated during storm tides, causing the suspension of all travel over them for periods ranging from a few hours to one week in exceptional cases. The surface material on roads of this type was also subjected to the wave action caused by high winds accompanying these storms and usually required resurfacing after each storm. Oyster shells are the best material for this purpose because they are affected but little by this wave action.

The more recently constructed roads have been built with solid fill reaching 1 or 2 ft. above the highest storm tides, and their construction is substantially as follows: Banks of meadow sod are built along each side of the road, having a top width of 2 ft., and with the outer face sloped at from 30° to 45° from the horizontal. The sod composing the outer face is laid in regular order, similar to masonry, with the grass side out. The grass growing on the outside of these banks forms a protection against erosion, during the storm tides. The slope of the outside face of banks should never exceed 45° with the horizontal, otherwise the grass will die, and the sods, having nothing to protect them, will dry out and gradually disintegrate, exposing the sand fill to the wave action during storm tides and causing the eventual elimination of the road.

The sod for building the banks is usually taken from within the line of the road, and should not be taken from the outside of the bank line as, when filling is in progress, there will be no lateral resistance against the base of the bank to counterbalance the horizontal component of the resultant pressure on the bank, due to the sand fill. In some instances, where sod has been removed from outside the banks, the bank, including the meadow sod on which it rests, has moved laterally on the underlying mud until the gap caused by the removal of sod has been entirely closed.

When sod is not available along the line of work light wooden bulkheads are built to retain the fill. These are constructed by setting piles 3 to 6 ft. c. to c., their point penetrating into hardpan just far enough to insure against lateral displacement at the bottom. The tops of opposite piles are tied together across the roadway with small iron rods through each pile, with washers and nuts for bearing against the piles and having turnbuckles under the middle of the road. Roads thus constructed are left unprotected, the entire construction being considered of a temporary nature. For a bearing, light stringers are placed both along the tops of piles and at the meadow surface, for which surface is used 1-in. pine sheathing, doubled with joints, lapped, and extending to the hardpan, when it lies close to the surface; or, where hardpan lies too deep below the meadow surface to permit its being reached with a single line of sheathing, as is sometimes the case, the sheathing is driven only a short distance below the meadow sod, thus allowing the sand fill to take its natural slope in the underlying mud which is displaced laterally to make room for it. Material for fill is usually obtained by dredging from riparian lands lying under the numerous bays and thoroughfares, some of which are usually close enough to be available. This material, which may be either sand of the character found on the beach, or gravel or clay, is pumped by suction dredges, equipped with centrifugal pumps, through a riveted steel discharge pipe to the line of work, which may be located as great a distance as a mile away from the dredge. The solid matter will be only about 10% of the discharge of the pipe, the rest being water, for which suitable openings in the banks must be provided so as to permit it to readily drain off the road and eventually return to the tidal waters. The fill material generally used, when first deposited, is quite similar to quicksand, and requires several weeks to drain off sufficiently to admit of the construction of the roadway surfaces.

As filling progresses the meadow on which it is deposited will be found to have settled more or less, dependent upon the solidity of the meadow sod and the underlying mud. As a rule, this settling amounts to an average of only 6 ins. or a foot, and again, if the meadow is soft the fill will settle until it finds solid bearing on hardpan, displacing laterally the underlying mud, which displacement is resisted by a more solid stratum of mud or by an area of hardpan lying at a higher elevation than that under the fill, causing a vertical displacement on either side of the road, which is indicated by the rising of the level of the meadow in the form of a wave parallel with the road adjacent to the sides of the fill. This settlement may occur gradually or sometimes occurs in a single night, necessitating continuous filling until equilibrium is established and the proper elevation of fill maintained.

The occurrence of this phenomenon was observed on a section of road, 2,750 ft. long, built at Chestnut Neck, N. J., in 1909. This road was at that time built up to a height of 2½ ft. above the surrounding meadow and has now settled for 2,500 ft. of its length until the surface of the road is practically level with the meadow. The fill material for this road was obtained from borrow pits on the mainland, adjacent to the end of the road. This particular section of road has been improved at two different times with state aid. It was completed about 15 months ago, the work being done in accordance with the standard specifications of the state of New Jersey. Twelve months after the road had been completed and accepted by the Board of Chosen Freeholders, the majority of the Board inspected this section of road for the purpose of final acceptance, and to their surprise they found it in the condition above described. A meeting was called and the existing condition discussed, the questions being asked the writer: "Did the contractor strictly comply with the plans and specifications, including the making of the required amount of fill?" and "If the contractor was responsible for the settlement of the road?" These questions were answered by stating that the road had been constructed, in every respect, in accordance with the requirements of the plans and specifications, and that the responsibility of the contractor for maintaining the roadway at a given level for twelve months guaranty period after completion was a legal question. The liability of the contractor for the settling of the road was then submitted to the county solicitor for his opinion, and the solicitor inquired if the plans and specifications could have been prepared so there would be but comparatively little settlement, to which the reply was made that they could be so prepared, but that the cost would be approximately four times greater than the cost of the construction as specified, but that the more expensive construction would be a saving to the county in the end.

For the better construction the method to be employed would be substantially as follows: Drive piles of any sound material to penetrate the underlying stratum of hardpan to a depth of not less than 6 ft., the number of piles necessary to carry the load to be determined by the engineer. After the piles have been driven, stringers to be fastened to the piling below the meadow level, or to such depth that pile and stringer would be constantly wet. Upon the stringers, either poles or plank shall be placed close together, and after this has been done deposit the earth to any height required. This method is only suggested for use in exceptional cases, similar to those which confront Atlantic and Burlington counties at the present time, especially Burlington, on the shore road across the meadows leading from Chestnut Neck to New Gretna.

Referring to the general construction of county roads, the road metal surface may consist, of course, of any material determined upon and placed on the road in the usual manner. The only material thus far used in Atlantic County being gravel, of which there are large deposits and of excellent quality on the mainland.

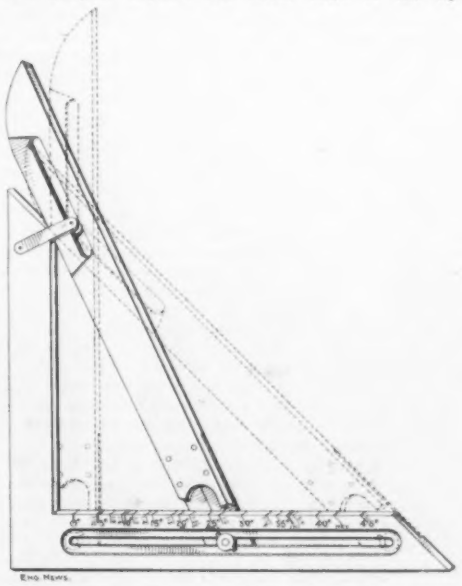
Due to the excessive wear on gravel roads by motor car traffic, and the resulting excessive cost of maintenance, Atlantic County has about completed the laying on Meadow Boulevard, which is the only highway leading from the mainland into Atlantic City, 6-10-mile of Warrenite road, a bituminous pavement, laid under the patents of Warren Brothers Co., and which is a modified form of bitulithic pavement and designed for use on state and county roads. The Warrenite road is of similar construction to the bitulithic, except that the latter is designed for use on city streets which are subjected to heavier traffic. If this material proves a success, which there would seem to be not a questionable doubt, the same material will doubtless be used on the remainder of this driveway for an additional distance of 4½ miles.

An Adjustable Triangle for Draftsmen's Use.

The adjustable triangle for draftsmen's use shown in the accompanying cut is a 45° triangle so arranged that one end of the hypotenuse can be slid along the base to make any angle with it between 45° and 90°. At the same time the hypotenuse makes angles between 45° and 0° with the upright leg.

The base member of the triangle has a slot, parallel to its ruling edges, in which slides a round pin fixed to the end of the hypotenuse. The upper end of the hypotenuse is slotted and slides on a pin fixed to the end of the upright leg. The blades or legs of the triangle are of maple wood and all the metal fittings of German silver. The end of the pin projecting up through the slot is threaded and carries a thin, modified wing-nut. A quarter turn of the nut is sufficient to free the pin or to bind it firmly at any point along the slot.

The upper end of the hypotenuse blade is cut off along a flat curve so that it can in no position project beyond the outer edge of the upright. This enables the use of the triangle with either the base or the upright against the T-square blade.



A Draftsman's Triangle Adjustable for Any Angle.

Graduations in half-degrees on the upper edge of the base mark the correct positions of the hypotenuse to set it at any angle between 0° and 45° with the upright. One use suggested for the triangle is in laying out large lettering, and positions are marked for drawing the sloping lines of the letters, A, K, M, N, V, W, X, and Y.

Many other uses will suggest themselves to draftsmen. The two opposite sides of a ditch or embankment, having the same slope, can be drawn at one setting by simply reversing the triangle. It should be remembered, too, in this connection that the triangle can be set at once to any desired slope without making any measurements. Another use is the convenient transfer of a given angle from one drawing to another.

Much of the work for which this triangle is advantageous can, of course, be done in other ways. The Universal Drafting Machine, on account perhaps of its cost, is by no means universally used, and probably most of the work for which the adjustable triangle is best suited is now done with the adjustable-head T-square. The adjustable triangle, however, has some obvious advantages over the adjustable T-square. The triangle is more quickly adjusted, and very few T-squares in use have protractor attachments to permit direct settings to a desired angle. With the T-square set at any considerable angle, a good deal of the drawing-board, in the lower left-hand and one of the right-hand corners, is inaccessible, while the adjustable triangle is available for use on any part of the board.

The triangle is the invention of Mr. Robert A. Suss, 7 East 47th St., New York City.

Coal Mine Surveying and Engineering.*

The tendency in coal mining in Indiana, as well as in other districts, is towards increased capacity of the individual plant. Several mines in this State are now producing from 1,500 to 2,000 tons daily, whereas five or six years ago, 1,000 tons was thought to be a large daily capacity. The larger capacity has been accomplished principally by increasing the size of the mine car and hoisting shaft, by the installation of more modern machienry for cutting and hauling the coal (such as electric mining machines and locomotives), and by more intelligent supervision of mining operations by the engineering profession.

Until a few years ago a mining engineer was practically unknown around an Indiana coal mine, and it was customary for the mine owner to employ a mine surveyor once a year only to survey and map his property, in order to comply with the mining statutes. As so little importance was attached to this work, the surveyor himself was inclined to be careless and run his survey in a manner that required the minimum amount of effort on his part, relying entirely upon his compass needle for bearings. The compass needle is very unreliable in a coal mine, owing to the excessive amount of magnetic attraction due to steel rails and live wires near the instrument, so that the final result of the surveyor's efforts was a rather inaccurate record of a very haphazard system of mining.

The surveyor merely followed after the mining development has already been driven out and recorded approximately conditions as he found them. This was much the same as if a railway should send out a track foreman and gang with instructions to build a road approximately in a certain direction toward a given point, but without any stakes or levels to guide; and after the line had been constructed in this fashion to send the engineer or surveyor to make a survey and map of the line.

Of late, however, the advantages of applying engineering principles to coal mining are becoming generally recognized, and now the mine surveyor instead of following after (and recording) mistakes goes in advance and shows the way to avoid them by following a plan carefully laid out by the engineering department. More accuracy is required from the mine surveyor, and although he is handicapped by having to work in the dark entries and rooms of the mine where the vein is generally so low that he must walk and stoop, his surveys are now closed up with a nicety that compares favorably with work done on the surface.

This brings us up to the question as to how these surveys should be made. In the first place, a true bearing for some base line should be established by making an observation on one of the polar stars at extreme elongation. This insures a permanently accurate record of the survey which will be valuable for future reference. This is not absolutely necessary or essential for the immediate development and working of the mine, as the compass reading on any line assumed as base can be taken as a base course and all subsequent work on the surface and in the mine can be referred to it, thus carrying any original errors through the entire survey.

After this base line has been established, the surface survey should usually be completed before starting with the underground work, although the latter may take precedence. For the surface survey it is necessary to locate accurately the boundary lines of the property, all railways crossing it, all public roads, town or city lots and streets under which the mining operations may extend, all buildings of every description (including those belonging to the mine), all reserves, reservoirs, streams, and rivers.

A topographical survey of the surface is also useful and often absolutely essential where the coal lies close to the surface and there is danger of flooding the mine by reason of a subsidence in some ravine that carries a large volume of water during wet seasons. Failure to give proper attention to this one particular has been and is now one of the most serious sources of danger and expense in operating old properties whose developments were started many years ago.

With the surface survey complete, the surveyor must establish the bearing of some base of reference line in the mine from which the mine survey can be extended. If the mine is a slope or drift, it is only necessary to run a surface line up to the opening, set up the transit and sight a line directly into the mine workings. If, however, the mine is developed from a shaft (and there are hardly more than half a dozen slopes and drifts in Indiana), the problem is more difficult. It can be handled in one of several ways, of which we will describe the two that we consider the best.

In the first, it is necessary to have two shafts open to the coal vein, in both of which plumb lines can be suspended. One of these will be the main hoisting shaft, the other the escape shaft (or ventilating and escape shaft combined). The plumb lines in both shafts can be dropped from points whose position can easily be established from the surface survey and the course between them calculated. No. 20 copper wire has been found to be very satisfactory as a plumb line and it should be held taut and as free from vibrations as possible by suspending at the end, just clearing the bottom of the shaft, a heavy weight swung in a bucket of oil. These two plumb lines can then be connected underground with a transit survey and the bearing of any one of the connecting courses calculated.

Ordinarily, however, the escape or ventilating shaft is not available for plumbing, as the escape shaft is usually obstructed by a stairway which occupies the entire area and the air shaft by the fan hood which completely covers it.

It becomes necessary to work from one shaft only, in which case (using the other method which we recommend) two, three and four plumb wires can be used. This method is described in the "Coal and Metal Miners' Pocketbook" (page 72, case 3), and in the illustrating example four wires are used. We think that three wires, properly placed, are amply sufficient to insure accuracy, and we will describe the operation with that number.

(1) Establish a reference line across the top of the shaft by setting the instrument at some station about 25 ft. from the side of the shaft and sight across to a point about the same distance from the other side. We will call these two points (A) and (B). Then suspend three wires at (C), (D) and (E) in the shaft (as before described), so that (C D E) will form the largest triangle possible in the shaft area. Then sight from (A) to all three wires, referencing the sights from the line (A B), and measure carefully the distances to all three of these wires from the transit station. Move the instrument to (B) and repeat the operation. Then calculate the position of the points (C), (D) and (E), and the bearings of the lines joining them. The calculations from the observation at (B) should check those from (A). If they do not, repeat the readings or establish another reference line and make an entire new set of observations. Measure carefully the distances between the three wires as an additional check.

This completes the top work and the instrument can be moved to the bottom and set up in the entryway leading from the shaft, at about the same distance from the wires, as on the surface. Then sight across the shaft bottom and locate another point on the other side of the wires. These two points we will call (F) and (G). Measure the distance between the wires on the bottom and compare with the same measurements on top, and repeat the same observations from (F) and (G) as were made on the surface from (A) and (B). Reverse the calculations and there will be three calculated locations from (F) and the same number for (G). If these agree closely, take the mean and figure the course (F G), which will be the reference line for all of the underground work.

In all observations upon these plumb lines at the shaft bottom, it is necessary to split the swing of the wire with the cross hair in the instrument, as it is impossible to keep the wire absolutely stationary where the shaft is of any considerable depth.

In some shafts the difficulties of plumbing are greater than in others and where a great deal of water is encountered, which (falling on the wires) causes them to swing and vibrate irregularly, it may be advisable to use four wires and two reference lines on the surface as a check on location. This will give the mean of four calculated locations for each wire on top and the mean of six calculated locations for each transit point on the bottom.

After this first reference or base line is established on the bottom, assume one of the transit points at one end of the line as Station O, and proceed with the underground survey. This work can best be accomplished by a squad of three men (instrument man, foresight man and backsight man). The first directs the party, handles the instrument and makes notes. The second and third give the sights, set the stations and handle the measuring tape. The stations should be set in the roof by drilling a ⅝-in. hole about 3 ins. deep, into which is driven a wooden plug. In the plug is set a spud made from a horseshoe nail, from a hole in which a plumb bob is suspended. The instrument is sighted on the plumb bob cord, which is made visible to the transit man by holding a light back of it. The illumination of the string can be improved by interposing a sheet of white paper between the light and the cord.

The stations should be numbered consecutively, beginning with Station O at the shaft bottom. The numbers should be marked with white lead on the pillar next to the station. A white circle should be drawn around the station on the roof, in order that it may be more easily located.

In setting up the instrument at any station, suspend a plumb bob from the hole in the spud and set up the instrument so that the center mark on the telescope is directly beneath the point of the plumb bob. Set the vernier at zero, take a back sight, plunge the telescope, turn a right or left angle and sight on the station which is set ahead. These sights should be made as long as possible, although probably 600 to 800 ft. will be the maximum distance between stations. The bearing of each line is, of course, figured from the bearing of the preceding line. These bearings should be checked by the compass reading wherever magnetic influences do not seem to be disturbing the needle. Measurements between stations should be made in much the same manner as they are on surface surveys, care being exercised to keep the tape level.

In running a line down an entry, take pluses to all openings off of the entry, making measurements from the transit line to the rib and pillar at each station, also at any point between stations where there is any irregularity in the course or width of the entry.

Run a transit line through all break-throughs that are open, so as to tie up with transit line in the parallel entry. These ties should be made wherever possible and it is especially advantageous to take a sight and measurement to all drill holes which may be encountered in developing the property, as it is then possible to obtain a further tie with the surface survey. The allowable error in closing mine surveys should not exceed one minute for angle, 1 ft. in 5,000 ft. for traverse, and 0.10-ft. in 2,000 ft. for level work.

For developing the mine, sights should be set in every entry. These sights consist of two points set in line about 18 to 24 ins. apart so as to strike in the center of the face of the entry. These points are set the same as transit stations and the entryman can (by dropping weighted strings from them and by illuminating the front string with his light) determine whether or not he is driving on the proper line.

Sights should also be set in every third room. As so much accuracy is not required in room work and it is possible to move the instrument away from magnetic influence, it is more convenient and entirely satisfactory to use a compass for setting these sights.

In measuring up rooms, keep the tape in line with the sights, taking pluses to all break-throughs, as well as to any irregularity in the room, measuring the width of the room at the face and wherever there seems to be any irregularity. In rooms where sights are not located, run the tape line as nearly as possible at right angles to the line of the entry.

In addition to the transit survey, levels should be taken every 50 ft. in at least one of each pair of entries. All unusual swags or dips should be noted closely and bench marks should be established at frequent intervals. These bench marks should be set on points that appear solid and permanent, in the roof, on the bottom, or in the coal on the side of the entry. They should not be set in a shale roof that is apt to cut and fall, nor in a bottom that is soft and inclined to heave. In the latter case, it is difficult to find a suitable place for a B. M., as the weight of the overlying strata is apt to force the coal pillars down into the soft bottom starting what is known as a squeeze. In these cases the top and the bottom, as well as the coal itself, are all on the move, so that a bench mark in this affected territory is useless and it will be necessary to run a new line of levels down the entry.

All levels in adjoining mines should be referred to the same surface B. M. which should be referred to sea level if possible by tieing up with some railway or city B. M. that has been accurately established. The leveling work in the mine can be handled very nicely by two men, one with the instrument and one with the rod. The rod used is only 3 ft. long, sliding out to 5 ft., and readings can be taken either on the top or bottom of the vein. In the former case, the rod is held upside down and the reading is added to the height of instrument. All profiles and contours, however, are based on the elevation of the bottom of the coal vein.

All prospect drill holes on the surface should be leveled and the elevation of the underlying coal calculated. This information is especially valuable in determining in the first place where the shaft should be sunk, and later how (and in what direction) the most economical development should be driven.

Copious notes and detail sketches in connection with all the survey work should be made. For room work a separate book should be used, in which should be drawn a continuous sketch of all rooms, showing the connection with the entry and with adjoining rooms.

After the field work is completed the office work consists of traversing the survey and plotting the map by the use of coordinates. A convenient scale for this work is 200 ft. to the inch, although the State Law requires a scale of 100 ft. to the inch.

The mine map should show the surface survey as well as the underground workings and in addition to the actual survey data (including the levels and contours) other information should be noted, such as haulage roads, ventilating currents, overcasts, trap doors, electric trolley and power lines, water and compressed-air pipe lines, etc. As it is difficult to show all of this information on one map, it is well to show the different items on separate blue prints, using colored inks on the prints. The more information of this kind that is noted on the map, the more valuable it is to the engineer for watching the mine's development and extending his plans for its expansion and economical operation.

*Abstract of the report of the Committee on Mining, presented at the annual meeting of the Indiana Engineering Society, Indianapolis, Jan. 12, 14, 1911. Committee: Alfred M. Ogle, Jr. (General Manager of Operations, Vandalia Coal Co.), Indianapolis; Louis Meyer, Boonville, Ind.; Fred. Rush, Terre Haute, Ind.

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The report of Mr. Bion J. Arnold to the Mayor of Pittsburg, on improving the passenger transportation there, has just been made public. It is indeed a formidable document but one of universal interest to engineers since it shows a broadly useful scheme of diagnosing urban transportation troubles and the application of the method to a particular instance—Pittsburg.

Because of space limitations, we have presented in this issue only the general discussions; the portions bearing more immediately on the Pittsburg situation will appear next week.

Many engineers, experienced in public-utility matters, seem to feel that, before they can risk an opinion as to the adequacy of a given service and the reasonableness of a given rate, an appraisal of the property of the public-service company and a study of it as a "going concern" must be made. Such a basis for an opinion, of course, is the soundest yet devised, but it requires a heavy expenditure of money and involves a long delay. There are some cases, surely, where inadequacy or unreasonableness are manifest and the needs are so pressing that refined methods are not necessary to show that something ought to be done. Under these conditions is it possible to place one's finger on the sources of weakness and apply emergency remedies without the loss of time for complete engineering and legal analyses? Mr. Arnold has answered this question affirmatively and applied his ideas to the Pittsburg case.

To the traveling public the troubles were self-evident and needed no sharp eye and keen mind to detect them. There were overcrowded cars on some streets and cars half or a quarter filled on others; there was continual congestion and delay at important centers; transfers were so limited that the choice of double fares or inconvenient routes discouraged travel; many cars were in poor repair and even dangerous; a $2,000,000 deficit had been accumulated by the company. In response to popular clamor, the municipal officers urged the company to improve matters, but the company found its hands bound by financial stringency and municipal harassment. The result was a deadlock and no method of breaking it and securing needed improvements was in sight.

Mr. Arnold's method for a quick location of the seat of trouble, and recommendation of the remedies available, consists of (1) a study to see in what ways the system may be operating in conflict with recognized engineering and economic principles, (2) a comparison of the company's latest and previous operating records, (3) a comparison of the district in question with other similar districts as to general growth and development of business, (4) a comparison of the company's operation with the records of companies in these similar districts.

The Pittsburg report shows that all the expense of changes from horse to cable and cable to electric traction have been capitalized, that in the course of consolidation dividends have been guaranteed on watered stocks, that extensions into new territory have been unwisely made, that the routes are the result of chance growth and not of definite plan. The fundamental defect is shown to be financial—too high fixed charges and failure to provide for depreciation from earnings.

Comparisons with other cities show that the general increase in population and the growth of business in the Pittsburg District has been healthy, that the district may be expected to double its tributary population in 35 years, with corresponding quadrupled earnings from the transportation of passengers, that Pittsburg is conspicuous for its limited use of transfers. What have been called serious barriers to adequate service—scattered business and residential centers and rough topography, for instance—Mr. Arnold considers may ultimately prove advantages in developing short-distance traffic and in arranging equipment to secure most advantageous loads. The city in its eagerness to secure the benefits of electric traction years ago, let down the bars and granted franchises so liberal that today it has not common rights to its important streets.

The present deadlock can be broken only by wise public regulation of the public utilities of the district, reports Mr. Arnold definitely and unmistakably. With that secured, the city need not hesitate to grant the additional privileges necessary for rerouting cars; the company can secure new funds for rehabilitation without increasing capitalization; a reorganization can be effected on a basis of fair return upon actual investment; depreciation may be compensated for; and harmonious cooperation between the public and the company may be established.

It seems to us unfortunate that many of the estimable gentlemen and estimable newspapers who are opposing the fortification of the Panama Canal should assume that the decision to fortify it implies distrust or unfriendliness toward our neighbors in Europe. Such an assumption is entirely unnecessary. A householder may keep a revolver in his residence as a means of defense against burglars, without any implication that he distrusts his law-abiding neighbors.

If European nations alone were in question, the safety of the canal could very likely be ensured by International treaty; but that is not at all the situation. A very considerable proportion of the nations of the world have not yet progressed to the point where they have at all times stable, reliable and responsible governments. An illustration of that fact exists at the present time close to our own borders.

Speaking before the American Society for the Judicial Settlement of International Disputes by Arbitration last month, President Taft said:

> We do not believe that the point has been reached in which all nations are so constituted that they may not at times violate their international obligations.
>
> The works of the canal are of such a character that a war vessel might easily put the canal out of commission. We have the treaty right to erect fortifications there, and fortifications are the best and most secure method of protecting that canal against the attack of some irresponsible nation or armed force.
>
> It is said that we could neutralize the canal and by inducing all nations to agree not to attack the canal secure its immunity from injury. But the trouble is that nations are quite as likely as men to violate their obligations when under great stress, like that of war.
>
> I would like to invite attention to an interesting incident within the last month. Suppose a "Dreadnought" under the command of the men who have recently been in command of "Dreadnoughts" were to seek entrance to that canal by force.
>
> Because we have the means of defending the canal is no reason why we should not neutralize the canal completely, if that be wise.

Multi-Control of Water-Works by State Boards in New York and Other States.

Should state control of water-works, under either private or municipal ownership, be vested in public-service commissions, state departments of health or state water-supply commissions? The question is raised, or more properly the need of discussing it has been suggested to us, by a number of recommendations for increased authority included in advance pages of the report of the New York State Water Supply Commission for the year 1910. Before quoting the recommendations it may be well to review briefly the general progress of central or state administrative control of water-works in this country, and then to discuss somewhat fully the fitness of the three kinds of state boards to exercise this control.

Three quite distinct lines of state control of water-works have thus far been attempted. These relate to: (1) the sanitary quality of the water supplied; (2) the apportionment of water to different municipalities or companies; (3) the regulation of rates, general character of service and capitalization.

The sanitary quality of public water-supplies was the first element to be brought under effective state control. This control was vested in state boards of health, with Massachusetts leading the way. From Massachusetts the sanitary control of public water-supplies has spread until, in greater or less degree, it is now vested in the state boards or departments of health of all our most progressive states.

Within five years or so the states of New York, New Jersey and Pennsylvania have created State Water Supply Commissions, primarily to control the acquirement of rights to water for municipal supply, or to arbitrate between rival claimants to the same drainage area. At the same time, these boards have been made, though rather tentatively or provisionally, the general conservators of the water-supplies of their several states, regardless of the purposes to which those supplies might be devoted.

Control of water rates, general character of service and capitalization of private water companies have been given to the public-service commissions of a number of states, including Wisconsin (in 1907), Maryland (1910), and New Jersey, in a very limited way (1910). Apparently the Oklahoma constitution of 1907 gave the Corporation Commission of that state a large measure of control over water companies, under various blanket provisions embracing all incorporated companies. In 1909, both the rates and the general character of the service of private water companies in Massachusetts were vested in the State Board of Health. It may be added that the Massachusetts Legislature exercises strict control of municipal bond issues for water-works purposes and at the same time adjusts rival claims to the same general source of supply, being guided more or less in the latter by the State Board of Health.

From the foregoing brief outline it appears that many of the water-works of the country are under the jurisdiction of from one to three state departments. Broadly, sanitary matters are controlled by state boards or departments of health; apportionment of water between cities, by state water-supply commissions; and rates, general character of service and capitalization, by public-service commissions. Sanitary control through health boards takes the lead, both in time and in extent. Apportionment of water and control of rates, service and capitalization seem to have originated at about the same time and to have extended at about the same rate. But if one considers public-service commissions and water-supply commissions as a whole the former are far more extensive and powerful than the latter.

There is every reason to believe that the three forms of state control under consideration will extend even more rapidly in the future than they have in the recent past. Other things being equal, obviously it would be preferable to consoli-

date all this control in a single board; and, next to that, in two boards. If, owing to conditions peculiar to any given state, there seems to be good and sufficient reasons for subjecting water-works to the control of three independent state boards, then great care should be taken to see that the distribution of control is so effected as to cause the least duplication of work and expense, and the least conflict of authority.

Let us see how well fitted each of the three classes of boards is to exercise all three lines of control.

State boards of health exist now in every state of the union, for the express purpose of conserving the public health. The best of these boards have well-manned and well-equipped engineering, chemical and biological or bacterial departments. In the past, a large part of the most efficient and most beneficial work of state boards of health has been in the sanitary control and protection of public water-supplies. The work includes the control of sewage disposal, as well, and is closely related to that of the divisions of communicable diseases and vital statistics, which fall under the same board. Where state health boards have seemed to fail to control the sanitary character of water-supplies the underlying causes have been lack of authority and funds rather than the need of action by another board.

The apportionment of water to rival municipal claimants is a relatively simple task, and one which can be readily performed by a state board of health, with the aid of its engineering department—all the more readily where plans for all new or additional supplies must be approved by that board in any event.

In like manner, the general character of water service might be supervised by a state board of health without difficulty, especially as regards quantity and pressure.

Rates and capitalization have little or no relation to the normal work of state boards of health, and if divided state control of water-works is to be permitted, may well go to any other state board better qualified through function or equipment to deal with such questions.

State water-supply commissions are new and few. Unlike state boards of health and public-service commissions, they have no functional relation to anything but water. So far as water-works alone are concerned, everything that water-supply commissions do can be done just as well, if not better, by either state boards of health or public-service commissions. Moreover, by no reasonable stretch of the imagination could a state water-supply commission perform all the functions of either one or the other, much less both, of the two state departments which it has sprung up to rival.

The only justification we can see for creating state water-supply commissions, instead of enlarging and strengthening the powers of state boards of health and public-service commissions, one or both, is the desire to place water, as one of the greatest natural resources of any state, in full control of a special commission, charged with conserving and utilizing it to the utmost for the benefit of all the citizens of the state.

That water-supply commissions might be created, with powers, staff and funds competent to protect the sanitary character of water-supplies, apportion water to rival claimants and regulate rates, service and capitalization, it would be idle to dispute. What is open to serious question is whether these powers of state control cannot be exercised by state boards of health and public-service commissions jointly, with greater efficiency and less cost; and whether the work of health boards, at least, would not be hampered, or, perhaps, crippled, if the sanitary control of public water-supplies were taken from them.

Coming now to the fitness of public-service commissions to control water-works along the three lines under discussion, we can readily see that as at present organized they have no special qualifications for controlling the quality of water-supplies, nor for apportioning drainage areas between different cities, although they could readily provide facilities for such work. What the public service commissions are specially fitted for is the control of rates, character of general service and capitalization, for this is exactly what they have been created for as regards gas and electric lighting, transportation and other public services. In all these particulars they are daily gaining in facility, strength and public esteem.

The logical conclusion from what has preceded is that it is unnecessary to distribute the state control of water-works among three boards, but may be desirable to divide it between two. Since state boards of health and public-service commissions are both needed, and between them can exercise all three kinds of control, state water-supply commissions would seem to be uncalled for and undesirable, unless the principal reason for their creation is to act as general conservators or trustees of all the waters of the state. Even then, it is doubtful whether they should take sanitary control from the state boards of health and control over water rates, general service, and capitalization from public-service commissions.

Inasmuch as every state has a board of health and is bound to have a public-service commission within a decade or so, any considerable increase in the number of water-supply commissions, or in the powers of the few commissions already in existence, seems undesirable.

Having discussed our subject on general principles, let us now turn to the recommendations for an increase in its powers which have just been submitted to the Legislature in the annual report of the Water Supply Commission of New York State:

(1) That plans for obtaining additional water-supplies, as well as additional sources of supply involving the acquisition of land should require approval.

(2) That more effective means be provided for compelling the submission of plans.

(3) That the jurisdiction of the Commission be extended so as to cover constructive work after plans have been approved and its consent be required before a new plant is used.

(4) That water-storage plans for power purposes be required to be submitted for approval so far as the protection of water-supply needs and the public safety may require.

(5) That authority to regulate the service rendered and the rates charged by water companies and municipalities be given to the Commission.

(6) That the Commission be required to decide whether water-supply plans make adequate provision for the future protection of the source of supply from contamination.

(7) That the acquisition of private water companies by other private water companies, or by municipalities, or the consolidation of private water companies without the consent of the Commission, be prohibited.

(8) That the consent of the Commission be required for the acquisition of sources of water-supply in cases where the supply is to be used wholly or partly in another State.

If these recommendations were enacted into law the State Water Supply Commission would be given full control over both municipally and privately-owned water-works in New York State in every particular under discussion except that of capitalization—which would still be free from any state control.

We think the wisdom of this open to serious question. Either the State Water Supply Commission or the State Board of Health might better be given full sanitary control of the public water-supplies of the state. Both together have too little such control now. The little control exercised by the Commission (merely power to require proof of the purity of proposed supplies) might well be taken away from it and given to the Board, together with all other power now possessed or requested by the Commission, save that of apportioning common supplies to rival municipalities. Even this last is questionable, except as the Commission proves itself to be, or to become within reasonable time, a true conservator of all the waters of the state, regardless of their ultimate use.

The control over rates and general service, we believe, is a proper function of the Public Service Commission, rather than the State Water Supply Commission; and with control over rates and service the Public Service Commission might well be given control over the capitalization of private water companies.

If the New York State Water Supply Commission were restricted to the great tasks of water storage, development of water power, prevention of floods and general regulation of stream flow which have been tentatively delegated to it by the Legislature, it would have enough work for any single commission. If finally given authority and funds to carry on this work it may be advantageous for the Commission to control the disposition of the waters of the state among their various claimants, whether for municipal supply (as it now does), water-power, or the general amelioration of stream-flow conditions (as is contemplated).

We can see little advantage, however, in giving it control over "the service rendered and the rates charged by water companies and municipalities." So far as companies are concerned, this is a natural function of the Public Service Commission. State control over the services and rates of municipally-owned works is a new and big question, which has not yet been given sufficient consideration in any state to warrant its off-hand adoption.

We have come to our final conclusions on both the general proposition and the recommendations of the New York State Water Supply Commission with no little regret, since we should have referred to have had the logic of the argument, as deduced from fundamental principles, leave no alternative save state control of water-works through a single board.

Concerning the New York State Highway Commission and the Commission Plan of Conducting Public Works.

Hon. John A. Dix, Governor of New York, may be animated with excellent intentions in his crusade to abolish various State Commissions which have been carrying on public work in New York for several years. Good intentions, however, are said to be utilized for paving material in a certain locality. If Governor Dix cannot bring better proof of the excellence of his intentions, than he has furnished in support of his crusade against the State Highway Commission, unprejudiced people may doubt whether his intentions will pass inspection even as paving material.

The facts of the case are that the State of New York (which is spending some $50,000,000 in the construction of improved roads) tried the plan of placing its road work under direction of the State Engineer, tried it for years and found it lacking. Why? Because for one thing the State Engineer has more responsibilities laid on him already than he can properly discharge. Because the State Engineer's office has a new incumbent as a rule every two years. Each new State Engineer, unless he is to be a figure-head, must spend months familiarizing himself with the State road work (provided he finds time to give it any attention at all) before he can really assume responsibility. Meanwhile the road department and its whole organization is held in suspense. The engineers in charge of the work never know whether their positions are secure or not. Under such an organization, honesty and efficiency in the discharge of work receives no recognition. By a process of natural selection the road bureau is bound to degenerate to a political machine.

We might continue at much greater length but the whole situation may be summed up by saying that an extended trial proved that with the road work in charge of the State Engineer's office graft and inefficiency crept in.

In the light of that experience, the legislature of New York established the present State Highway Commission and placed the State road work in its charge.

And now let us return to Governor Dix's crusade. On Jan. 12, twelve days after assuming office, the new State Engineer, Mr. John A. Bensel, addressed a letter to the Governor criticising the work of the State Highway Commission. The Chairman of the Commission, Mr. J. Percy Hooker, replied to these criticisms on Jan. 14. We have found these letters so interesting that it has seemed worth while to reprint the major part of them:

Hon. John A. Dix, Governor, State of New York, Albany, N. Y.:

Sir.—I beg to call your attention to certain features in the specifications as issued by the Department of

Highways for the building of roads in various counties of the state under chapter 30 of the Laws of 1909.

These specifications are, in my opinion, defective, first, in that they provide that the contracts are to be let according to a lump sum bid by the contractor, but in addition to this, the Highway Commission reserved the right to make such changes in the plans and specifications as may from time to time appear to be necessary or desirable, and the changes from the amount of the quantities estimated in the specifications are to be paid for on unit prices nominated within limits by the contractor, but which limits are fixed by the estimate in the contract made by the engineers of the Commission, and from which estimates the contractor is not allowed to deviate more than 15% in some cases, or 20% in others. In other words, by this method the bids which are called for are not by the contractor as a free agent, but in the case of the lump sum bid the contractor is supposed to be a free agent. In the alterations of the contract which may be made at will by the Highway Commission, the prices are nominated within 15% or 20% by the engineers who have estimated the work which is to be let.

The amount of detail in the construction of the work prescribed is, in my opinion, unnecessary, in order to obtain the proper result in the building of roads and adds a large amount to the expense of such roads. In a road of about 6 ins. in thickness, these specifications prescribe from five to six different layers of stone in different sizes, making a most expensive job to execute, and also making a cost for engineering and construction greater, in my opinion, than is warranted by the results obtained. This cost of engineering amounts to something over 19% of the contract cost, which is higher than any work of this kind ever before known.

The specifications are also drawn with but little regard to the local material which could be used, and in some cases I note that last year, under practically the same specifications as the ones now in question, stone for the roads was imported from Morristown, N. J., at a cost to the state of something approaching three times what it would have been had local material been used, most of which was occasioned by the rates charged by the railroads.

I would further advise that the law under which these contracts were to be let prescribed that they shall be drawn by the Resident Engineers, but I find by inquiry that such is not the prevailing practice, and that primarily the plans, specifications and estimate of cost are drawn in this city, which would seem to be the reason why the use of local material on local needs is neglected and a uniform process of road construction is provided for which adds to the expense to which the state is put for the work to be done.

To sum up in a general way, I would respectfully advise that the contracts, in my opinion, which I have looked over provide for a method of construction which is entirely too expensive for the ordinary county requirements, and after considering the matter in some detail, I am of the opinion that from 50 to 80% of a greater mileage of road could be secured for the same money were the specifications changed to remove the uncertain elements from the consideration by the contractor, less finicky methods for construction provided, and advantage taken of the local materials for the use of construction wherever it were possible. Further, the contracts should be altered so as to provide for one type or class of bid, which would make it possible for the contractor to know exactly what he was required to do and leave him a free agent to nominate the price for which he was willing to do the work and allow the state to gain thereby in removing restrictions which are imposed by the present form of contracts in which the contractor is not a free agent in the nomination of his figure, and the state does not avail itself of the experience of the various contractors in nominating the prices for which they may be willing to perform the work which is called for.

Very respectfully,
(Signed) J. A. Bensel,
State Engineer.

Albany, Jan. 12, 1911.

Hon. John A. Dix, Governor, Albany, N. Y.:

Sir.—I acknowledge receipt of your letter of the 12th instant, containing certain criticisms by the State Engineer upon the specifications used by this Department in building highways, together with certain other matters, and I will answer the same categorically.

The first criticism is—"That the specifications are defective in that they provide that the contracts are to be let on a lump sum bid, and in addition thereto that the item prices for which additions and deductions are to be charged, must be within 15 or 20% of the estimated prices."

Section 130 of the Highway Law provides:

Each proposal shall specify the gross sum for which the work will be performed and shall also include the amount to be charged for each item specified in the estimate.

Mr. Bensel's criticism would seem to be in regard either to the use of a lump sum bid or to the use of item prices limited. As the law expressly provides that the contract must be awarded on the lowest lump sum bid, any criticism in that respect is futile. With regard to the item price bid limited, your attention is called to the fact that under the law it is obligatory that an item price be inserted for additions and deductions, and the only question therefore remaining is whether the contractor shall be allowed to insert such price without limitation and the state be bound thereby, or whether a reasonable limitation shall be placed upon the item price, leaving the contractor a free agent within those limitations. It must be borne in mind that the state is bound to award the contract upon the lowest lump sum bid, and having awarded the contract it is bound by the item prices for increases and deductions which are inserted in the proposal.

This Commission in adopting the form of proposal which is now in use, did so after a careful study of the conditions and having in mind the fact that the plan which Mr. Bensel seems to recommend in regard to the item prices for increase and deductions was thoroughly tried by his predecessors and abandoned as unsatisfactory.

The second criticism—"that the amount of detail in construction is unnecessary" must of course be largely one of opinion. The statement about the specifications requiring from five to six layers of stone is, I think, unjust, and unwarranted by the specifications.

One-half the thickness of the road, or the bottom course, is to be of No. 4 stone, the large size of stone. In the specifications drawn a year ago, the top course would have consisted of a mixed aggregate of No. 2 and No. 3 stone which, after the application of the bituminous product, would have been covered with screenings. Experience showed that this mixed aggregate of No. 2 and No. 3 stone resulted in portions of the road being entirely of No. 2 stone, and portions of the road being of No. 3, and it was thought wiser to provide that the No. 2 and No. 3 stone should be put on separately, thus providing for a more even distribution of material and insuring a more compact road without materially increasing the cost.

The State Engineer has failed to take in the fact that these sizes of stone comprise the entire product of the crusher, and the only method in which the entire product would be used. This is a feature indorsed by all road builders.

The third criticism—"that the statement is made that the cost of engineering is over 19% of the contract cost."

My answer to this is that he has been misinformed. The engineering cost in the last year, compared to the amounts paid to contractors, being only about one-half the figure stated by him.

The fourth criticism—"that the specifications are drawn with little regard to the local material which could be used."

I feel that this also must be absolutely characterized as misinformation, the only basis for such a claim being that we have standards for stone which may be used as road material. We require certain qualities to be present in the stone used, the bottom course not requiring as high a quality as the wearing course, but we have insisted that a sample of stone to be used upon the road should be submitted to this Department, and that it should pass the tests laid down. Our standards may be too high, but the disastrous results upon certain roads, in Cattaraugus and Ontario Counties especially, of using stone which did not come up to legitimate tests, made us feel that it was necessary to obtain proper material before we expended such large sums of money upon the building of highways.

The use of the word "local" is very indeterminate. Stone eight miles away from the highway to be built would frequently cost more, delivered on the highway, if the only method of hauling was a wagon, than the so-called "imported" stone from a distance of several hundred miles, if that could be delivered by train.

The specifications gone over by Mr. Bensel were for 67 different roads. Of these, 46 were to be entirely constructed of local stone, 15 roads were to be built with local stone, bottom course and top course of imported stone, and 6 roads were to be of both imported top and bottom course. Of the six roads which were to be entirely of imported stone, our records show that there was no local stone of any sort adjacent to the road, and in each instance the road was in such geographical position that stone from commercial quarries in nearby counties could be used at a reasonable and low price.

I am submitting to you herewith copy of the records as furnished by the Division Engineers in regard to stone conditions on each of the roads where imported stone was called for by the specifications.

Mr. Bensel states that the "Resident Engineers," according to law, are to prepare the plans and states that this is not "the prevailing practice."

The law states that the "Division Engineers" (an entirely different person than Resident Engineers) are to prepare the plans and they have done so in every instance.

His final summing up includes the general statement that in his opinion the present method of construction is too expensive, and that if the specifications were changed, from 50 to 80% more mileage of road could be secured for the same amount of money. This great increase of mileage of course would mean that the cost of each mile be correspondingly decreased. No material decrease in cost could possibly be attained by the elimination of such minor details as he suggests and could only be effected by the adoption of an entirely different method of construction than any now in use either in this or in any other state engaged in the construction of macadamized highways by state aid.

The question of cost is one which has received the constant and careful attention of the Commission during the entire period that it has had charge of this work. When the Commission commenced operations it found nearly 1,800 miles of macadamized roads which had been built during the past ten years and which by reason of entire lack of maintenance were rapidly becoming ruined. The ordinary method of macadam construction which was formerly entirely adequate could not effectually withstand the enormous increase in motor vehicle traffic.

The conclusion at which this Commission finally arrived, and which was reached only after a most thorough and careful study of the situation both in this and in neighboring states and as the result of extended correspondence and investigation in the conditions and methods obtaining in this country and abroad, was that the use of a bituminous binding material in the top course was absolutely essential and that the increased cost was more than offset by the decrease in the annual cost of maintenance and repair.

It must also be borne in mind that two-thirds of the total expenditure in the construction of a road consists of labor charge and that within a period of five years the cost of labor has increased 25%. Notwithstanding the increased expense for labor, the use of a bituminous binder and an increase generally to a 16-ft. width of macadam, it is clear that the average of contracts awarded has been at a much less figure than the increases above outlined would indicate; and it is the confident belief of the Commission that by this method of construction the cost of maintenance for the roads will be kept at an entirely reasonable annual amount.

The Commission's primary idea has been to safeguard the interests of the state and procure roads which shall be of the most advanced construction and the greatest durability, and the least annual cost, taking into consideration depreciation, interest charges and maintenance. To return to a cheaper form of construction means a recurrence of the same conditions which confronted the Commission in assuming charge of the roads. The use of local stone which is not of proper quality is no economy, but is on the contrary the greatest extravagance, and in no way can money be more foolishly expended than in prescribing unsuitable material for road surfacing.

The specifications used are the result of years of experimentation on the part of engineers who are making highway construction their life work, and it is most gratifying that the State Engineer has made no radical suggestion of changes therein.

In conclusion, your attention is called to the fact that each of the criticisms made by Mr. Bensel is either based upon a misunderstanding of the law as shown by his quotations and references, or he inferentially recommends the adoption of methods which have been carefully tried by preceding State Engineers while the work was in their charge and abandoned as unsatisfactory.

Respectfully yours,
STATE COMMISSION OF HIGHWAYS,
By S. Percy Hooker,
Jan. 14, 1911. Chairman.

Our readers can judge for themselves as to which of the parties to the above discussion makes the better showing and as to which would appear to be the most trustworthy agent to secure the efficient construction and maintenance of New York state highways.

We understand that many citizens of New York have already made up their minds upon this matter. From all parts of the state protests have rained down upon Albany against the displacement of the State Highway Commission. So numerous and so influential have been those protests that Governor Dix is said to be wavering in his crusade. If these protests avail to show him that good intentions cannot replace sound knowledge and that there are weighty reasons why great public works ought to be in charge of efficient commissions rather than elected or appointed officials, the State will be the gainer.

Engineering News is on record and has been for many years as an emphatic supporter of the commission plan of carrying on large government works. We support it, because experience in many different works carried out by cities, states and nation, has demonstrated its great advantages.

This is not saying that this or any other plan of government or administration can win success in the hands of dishonest or incompetent men. What we do say is that the chances of serious loss to the state through fraud or incompetence are much less with a commission of three to five men in authority than with one man in sole charge. This is one reason why the commission plan of municipal government is rapidly coming into public favor.

Furthermore, we feel safe in saying that the position of Engineering News on this question is the position of the majority of leading members of the engineering profession.

Engineers know by experience the vicissitudes that overtake every public work which has to have its whole administrative force upset by every election. They know what political control means to engineers and to the works on which they are engaged.

Ten years ago, when the construction of the New York barge canal was undertaken, Engineering News urged that the entire charge of the work be placed in the hands of a commission, preferably of engineers.

One of the chief supporters of the barge canal project at that time admitted that Engineering News' position was correct, but stated that political pressure at Albany was too strong to permit the passage of laws taking that work out of the hands of the Superintendent of Public Works and the State Engineer.

A compromise was, therefore, effected under which an "Advisory Board of Engineers" was created; and the supporters of the enterprise thought this would be sufficient to protect the public and secure honesty and efficiency in the work. In other words, as long as they couldn't get the substance of the commission plan of control, they would take the shadow!

That the commission plan ought to have been adopted at the outset is admitted now by those most intimately connected with the work. The retiring State Engineer of New York says in his report:

> A feature which results in a certain loss of time and of efficiency is found in the frequent changes of administration. Four State Engineers have so far had charge of this work and a fifth will shortly take office. The personnel of the Canal Board has been completely changed three times, and on the first of January will be changed for a fourth time. The office of Superintendent of Public Works has been occupied by three men during the progress of the work, and a fourth will take office on Jan. 1. The only continuing body which has had authority over this construction since its inception is found in the Advisory Board of Consulting Engineers.

The retiring Superintendent of Public Works, Hon. F. C. Stevens, says in his report:

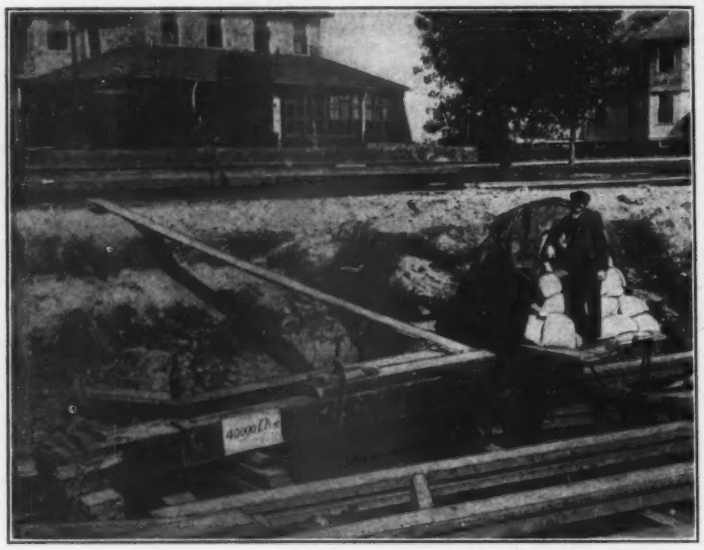
> I am aware that commissions are not popular, and, generally speaking, are not considered an economical means of conducting public business, and, generally speaking, I would not contest this point, but in the case of so great an undertaking as the barge canal work, it is my judgment that some method should have been devised which would have guaranteed a continuity of work under a head of recognized ability, and a separate commission for this purpose is the only method I can conceive that would guarantee such results.

Mr. Stevens says commissions are not popular. He is right. They are not popular with the politicians who want to use state appropriations for public works in the way that will best subserve their ends. They are not popular with the special interests who find some incorruptible commission in the way of their plans for a combination of business with politics. But if the taxpayers knew what engineers know, they would view with grave suspicion any public officer who starts out on a crusade for the abolition of commissions with the ostensible purpose of economizing the money of the dear people.

LETTERS TO THE EDITOR.

Applying a Load to Test Piles by Means of a Lever.

Sir: The accompanying photograph illustrates a convenient method of applying a test load to a pile by using a long beam as a lever, the fixed end being anchored to a number of other piles. A leverage of 3 or 4 to 1 may easily be obtained, correspondingly reducing the amount of loading material. In the case shown, bags of cement were used, greatly reducing the cost of the test.



LOADING TEST PILE BY LEVER APPLICATION.

Very truly yours,

DeWitt C. Webb,
Civil Engineer, U. S. N.

U. S. Navy Yard, Boston, Mass., Jan. 3, 1910.

The Work on the Panama Canal; Retaining Walls in the Culebra Cut.

Sir: I have just returned here from Panama, where I spent two weeks examining the canal work under the best possible auspices.

I paid particular attention to the Culebra Cut—walking through it with Col. Gaillard and seeing it from above as well, giving special attention to the slopes and action of the slides.

I have had in my experience much difficulty with slides and think I have a right to have an opinion about those at Culebra.

Since arriving here I find Engineering News of Jan. 5 and have read with much interest your editorial respecting the question whether retaining walls should be built at the sides of the Culebra Cut. I had already been informed of the reports of the engineers and geologists. I am in entire accord with your views as to the retaining wall. No retaining wall could hold those slides, and if it could resist them they would overtop it and tumble into the Cut. Anyone who has had any experience with such conditions will, after carefully examining those at Culebra, agree with you. I think reliance can be placed on the mature judgment of the engineers in charge, who are constantly on the work—observing all movements of material and getting rid of it in a way that enlists the hearty approval of every one and the greatest admiration for their splendid work. This remark applies to the entire canal work under their charge. I am glad to go on record as in full accord with the methods and manner of their work.

E. L. Corthell.

2 Felsenburg, Berne, Switzerland, Jan. 25, 1911.

[Since our note of Jan. 5 was published, we have been informed by one of the members of the Isthmian Canal Commission of 1901 that the proposal made by that Commission to build masonry walls at the sides of the Culebra Cut was influenced chiefly by the idea of protecting shipping. The width of the channel then proposed through the Culebra Cut was only 150 ft. and it was felt that the hulls of vessels might be injured by any accidental contact with sharp points of rock projecting from the sides of the Cut.

A fair idea, we believe, of what the Commission of 1901 proposed may be obtained from the late Geo. S. Morison's paper on the Panama Canal, presented before the American Society of Civil Engineers in February, 1903. Mr. Morison was one of the most prominent members of that Commission. A large part of Mr. Morison's paper was printed in Engineering News of March 5, 1903, and on page 222 of that issue is shown a typical cross-section of the Culebra Cut lined with masonry walls on each side, 46.5 ft. high, with a base of 16.8 ft. and a top width of 5 ft. In his paper Mr. Morison said:

> It is thought unsafe to allow the earth in this cut to be washed by the water of the canal. The French plans have recognized this and have provided for facing the slopes of the canal with masonry.
>
> It is desirable, if the sides of the canal are lined with masonry, to have this masonry nearly vertical, so that there would be no danger of a ship striking the masonry lining below water. These requirements are met by a special cross-section, which is shown in Fig. 3. The masonry walls may appear unnecessarily expensive, but their function is triple—they protect the slopes from the wash of the water; they accommodate the Panama R. R., and they provide a bench in case of accident on the slopes. These walls should be provided for a length of 32,000 ft.—about 6 miles. They would contain in the aggregate 1,200,000 cu. yds. of concrete masonry.

We may add that the Commission of 1901 had, of course, to work with such data as were then available. We have little doubt that were the problem to-day presented to the engineer members of that Commission. they would not approve their recommendations of ten years ago.—Ed.]

More Data on the Strength of Wood After Long Service.

Sir: The following data [reproduced in the subjoined table] may be added to the discussion of the strength of wood that has seen long service.

These white pine beams were from the chords of a Howe-truss bridge that was taken down after 18 years' service, during 14 of which the bridge had been covered. The wood was sound, and was thoroughly air-dry at the time of test, March, 1901. It probably contained 10% to 12% moisture.

The average elastic limit and modulus of rupture of the beams Nos. 1 to 9 were respectively 3,956 and 5,208 lbs. per sq. in. The records of tests by various authorities indicate that white pine beams of large size may be expected to have a modulus of rupture of 5,000 lbs. per sq. in.

W. K. Hatt.

Purdue University, Lafayette, Ind., Feb. 2, 1911.

RESULTS OF TESTS OF OLD WHITE PINE BEAMS.

From chords of Howe-truss bridge for Monon Route, in service for 18 years, 14 of these under cover.

I.—FLEXURE TESTS.—Load at Center.

	Dimensions of beams.		Elastic limit.		Rupture.		Modulus of elasticity, lbs. per sq. in.
No.	Span, ft. ins.	Section, ins.	Load, lbs.	Stress in outer fiber, lbs. per sq. in.	Load, lbs.	Stress in outer fiber, lbs. per sq. in.	
1	10 ..	5¼ × 12¾	26,000	4,438	27,500	4,696	1,320,000
2	11 ..	11¾ × 5	14,500	4,098	14,500	4,098	1,850,000
3	11 ..	12¾ × 6	18,000	4,280	18,500	4,320	1,587,000
4	11 ..	13 × 5¼	16,000	3,330	17,000	3,770	1,111,000
5	11 ..	12¾ × 6	18,000	3,740	20,000	4,240	1,157,000
6	10 6½	14 × 5½	17,000	3,521	20,000	5,989	1,090,000
7	10 8¼	12¾ × 5½	19,000	4,516	20,500	7,762	1,176,000
8	10 3½	12¾ × 6 9/16	20,000	5,026	22,000	8,727	1,435,000
9	8 ..	14 × 5½	20,000	2,671	23,000	3,071	837,469
10	10 ..	14 × 5½	8,000	1,333	9,100	1,518	703,318

NOTE:—Beam No. 1 broke at knot off center. All others broke at center on the tension side.

II.—COMPRESSION TESTS.—2-in. Cubes, Endwise.

From top of beam:		From heart:	
	4,400		3,900
	4,827		4,500
	4,700		3,988
	5,160		5,470
	4,825		
Average	4,782 lbs. per sq. in.	Average	4,464 lbs. per sq. in.

The Disastrous Explosion at Jersey City, N. J., on Feb. 1, 1911.

On Feb. 1, a few minutes after 12 noon, a great explosion occurred on one of the freight transfer piers of the Central Railroad of New Jersey at Communipaw, Jersey City, N. J. Several box-cars loaded with dynamite for lighterage to ocean-going vessels stood on the pier. Two lighters, one a gasoline launch of the E. I. Du Pont De Nemours Powder Co., who were shippers and consignees of the explosives, the other a small steamer leased by them for their lighterage work, lay at the end of the pier. The steamer was engaged at the time of the explosion in taking on a load of dynamite. The laborers who were transferring the dynamite were at lunch on the pier when the explosion occurred. Either the lighter or the car from which the dynamite was being taken exploded. The three half-tone views herewith, Figs. 1-3, illustrate the effects.

The explosion destroyed the end of the pier, the two lighters and the open car of dynamite. It shattered and damaged many other cars and nearby vessels, but did not detonate the other dynamite on the pier. The terminal trainshed and ferryhouse of the Central Railroad of New Jersey, a few hundred feet north, was shaken and damaged, several of its brick walls being cracked and much of the skylight glass of the trainshed broken. Much window-glass was broken in the lower part of New York City, a mile east, and the vibration of the explosion was felt strongly in the tall office-buildings there.

FIG. 1. SAILING VESSEL ON SOUTH SIDE OF PIER, COVERED WITH WRECKAGE FROM EXPLOSION.
(Photo by Pictorial News Co.)

FIG. 2. LOOKING NORTH FROM WRECKED PIER TOWARD TERMINAL STATION OF CENTRAL RAILROAD OF NEW JERSEY.
(Photo by Pictorial News Co.)

It has been stated by officials of the railway that the dynamite on the pier was not in their hands at the time of the accident, having already been delivered to the consignee for unloading. The powder company claims that the steam lighter carried a large amount of black powder without their permission, that the powder exploded, that the dynamite was frozen and could not explode, and that the many unexploded sticks of dynamite found scattered over the pier demonstrate this. The cause of the explosion is not known. Nothing definite has come to public notice as to the amount of dynamite on the pier at the time, but it is conceded that there were at least two car-loads, one of these being destroyed by the explosion, while at least one is known to have remained intact, although only a few hundred feet away.

Investigations of the accident are under way. The reports turned in by the Jersey City police led to warrants being issued for the arrest of four officials of the railway, three officials of the powder company, and the owner (and lessor) of the steam lighter into which the dynamite was being transferred. The Prosecutor of Hudson County has the case under investigation. The Bureau of Explosives of the American Railway Association, 24 Park Place, New York City, under Col. B. W. Dunn, detailed from the War Department, is also investigating, but its report will be private to the railways. It is asserted that the matter does not fall within the jurisdiction of the Interstate Commerce Commission on the ground that the railway had already made delivery of the freight. The Jersey City authorities say that no permits had been issued by them for storing or handling large quantities of dynamite on the pier. A bill has been introduced in Congress to direct the Bureau of Mines to investigate the explosion.

Some 30 lives were lost in the disaster. The exact number is likely to remain unknown.

FIG. 3. LOOKING OUT ALONG THE PIER WRECKED BY DYNAMITE EXPLOSION.
(Photo by Pictorial News Co.)

The Explosion at the New York Central Battery-House, Lexington Ave. and 50th St., New York City.

Light was thrown on the serious explosion of a battery-house of the New York Central & Hudson River R. R. in New York City, which occurred on Dec. 19, 1910, as reported in our issues of Dec. 22 and 29, 1910, by the Coroner's inquest on the victims, which was held during the past week and terminated with a verdict brought in on Feb. 3. The inquest brought out the testimony of eye-witnesses, officials and employees of the New York Central and of an administrative sub-organization known as the Grand Central Terminal, and two experts retained by the District-Attorney to investigate the accident; these experts were Prof. Charles E. Lucke, of the Department of Mechanical Engineering, and Prof. Henry S. Munroe of the School of Mines, Columbia University. Prof. A. C. Humphreys of Stevens Institute of Technology, the noted gas expert, was present but did not testify.

The testimony made it clear that the disaster was a great gas explosion, occurring through a remarkable chain of circumstances. The case as brought out may be set forth briefly as follows:

The battery-house, it will be remembered from our former account, occupied the northeast corner of the depressed terminal yard of the New York Central, and was situated at the southwest corner of Lexington Ave. and 50th St. It extended along 50th St. nearly 200 ft., the building being continued beyond this point as a transformer house. It was a two-story steel-frame brick-and-concrete structure, with lower floor about 10 ft. above street level, the front (50th St.) wall continuing down to the sidewalk and resting on the retaining wall which bordered the depressed yard. On Dec. 19, 1910, between 8 and 8.30 a. m., a violent explosion wrecked the battery-house, blew out the front wall and dropped parts of the battery floors and the entire roof for a length of about 100 ft., killing a dozen persons in the building and in the street nearby. Shortly before the explosion a train in the yard below had run into and broken a bumping-post alongside the battery-house, and had broken a bank of pipes carrying water, steam, compressed air and Pintsch car-lighting gas, directly below the house.

It appears that our account of the accident given in a news note in our issue of Dec. 22 was substantially accurate. The construction of the battery-house was shown in our issue of Dec. 29, 1910, by sketches from the architects' plans. In the form there shown it was built some four years ago. Subsequently, however, the building was modified by adding some temporary construction: (1) By enclosing the inclined driveway on the south side, flooring the driveway with wood planking and building a one-story shed extension in the 26-ft. space between the east end of the building and Lexington Ave.; and (2) by enclosing some of the space under the driveway to form closed storage bays.

The driveway story thus formed a long room nearly 35 ft. wide 12 to 15 ft. high, and about 125 ft. long, which was used as carpenter and tinsmith shop. Its ceiling was formed by the lower battery floor, consisting of steel plate-girders, 12-in. I-beams and concrete slab filling; the north wall was formed partly by the 50th St. retaining wall and partly by the stone and brick front of the battery-house; the south, east and west walls were of flimsy construction; the floor was formed by planking laid on the 12-in. I-beams of the driveway, or on blocking over these beams arranged to give a level surface, in two or three steps. In the southerly half of the portion under the battery-house, and in part of the shed extension on the east, the trough planks of the floor were covered with tongue-and-groove maple flooring. The room had ample windows along the south wall and in the two offices at the east end. The north wall under the battery-house was unbroken for its full length.

The bays under the carpenter shop were separated by partitions and most of them closed by a corrugated-iron front. These were used for general storage. Testimony given at the inquest as to the nature of the material stored there does not reveal anything that might have caused or contributed to the explosion.

No dynamite, gasoline or other volatile oil were present in either storage space or carpenter shop. Early rumors as to dynamite being in the explosion were found baseless.

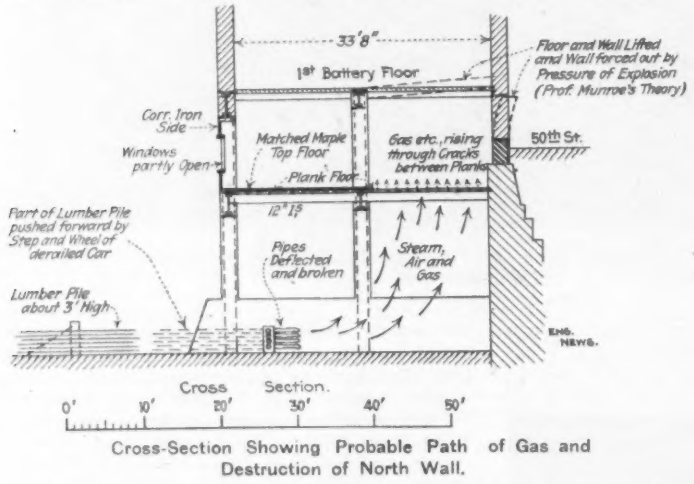
It was established that a train of five cars which was being run into Track 16, the fourth track from Lexington Ave. (the tracks are parallel to Lexington Ave. or at right angles to the long dimension of the battery-house), ran into the bumping-post just south of the building at 7.53 a. m., Dec. 19. This collision wrecked the bumping-post by breaking the two 100-lb. track-rails which sloped up from the track to the post, although these rails are made of special soft stock to be capable of being bent without injury. At the same time the forward truck of the train was derailed to the east; it stopped close up against the line of the building and did not reach the pipes carrying gas, steam, etc. But it happened that a day or two previously a pile of 8 to 16-ft. boards for the use of the signal construction forces had been stacked in the 6 ft. 4 in space between Tracks 16 and 17 (east of 16), parallel to the track. This pile was about 3 ft. high and lay with its north end fully 15 ft. south of the line of pipes. As the derailed truck ran along this pile, its forward wheel and the vestibule step caught in the upper part of the lumber pile and pushed the boards forward. These boards struck, bent and broke the four pipes which ran transverse to the track some two or three feet behind the southerly columns of the battery-house. The motorman operating the train neither examined nor reported the damage to the pipes.

Several persons noticed the steam and gas escaping from the broken pipes. Three or four trainmen who looked at the derailed truck paid no attention to the leaks, apparently, but the carpenters in the shop above, looking out after hearing the collision, saw the escaping steam and soon afterward smelled the gas strongly. The foreman carpenter, indeed, P. F. Solan, came down to track level, glanced at the break, and walked south along the line of pipes looking for valves to 49th St., where he found a valve in the steam line and shut off the steam, returning then to his shop. The gas was not shut off for some 20 minutes. It appears that the nearest gas valve was at 47th St., about 600 ft. south of the battery-house, and the carpenter foreman did not know where it was. Between 8 and 8.20 a. m. the four men in the shop continued to notice a very strong smell of gas, and opened all the windows, the last probably about 8.20. Persons on the street outside the building also noticed a strong smell of gas; and a few minutes before the explosion a policeman remarked on it when on the west side of Park Ave. at 50th St., fully 300 ft. away from the leak.

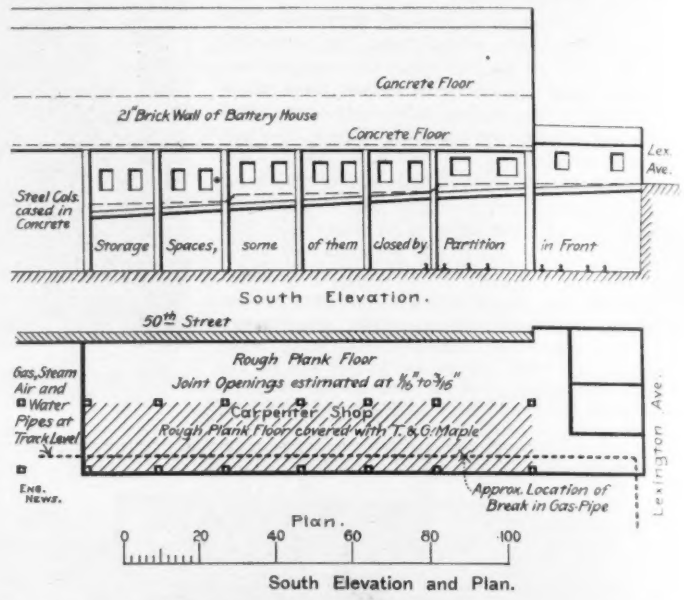
The engineer in charge of the gas-compressor station, at 47th St. and Lexington Ave., noticed an unusual fall of pressure about 8.05. The gas is stored in four tanks of total volume 6,896 cu. ft., of which three were on the line. The pressure carried varies from 10 to 12 atmospheres, and at 6.30 a. m., when the engineer came to work, was about 10½ at. At 8.05 or thereabouts it was about 9, and three or four minutes later it had fallen nearly to 8½ atmospheres. The engineer and his foreman did not learn where the leak was until about 8.15, when they closed the valve on the pipe leading to 50th St. The foreman computes that 10,000 to 20,000 cu. ft. of gas was lost at the leak.

Profs. Lucke and Munroe examined the premises thoroughly after the explosion, made experiments as to the explosive properties of a mixture of Pintsch gas with air, arrived at a definite opinion as to the nature and seat of the explosion, and made calculations from the observed effects to learn what pressures these would indicate. They testified therefrom, in effect:

That no evidences of explosion of dynamite or other high-power explosive appeared. That appearances indicated an explosion of broad extent, as from a room full of gaseous explosive mixture. That the seat of the explosion was the carpenter shop, throughout its extent. That the pressures required to bend the floor I-beams and force out the northerly wall were such as might easily be developed by a gas explosion. That a mixture of Pintsch gas with air is explosive within a gas-percentage range of 5 to 13%, and has maximum power at about 9%. That Pintsch gas weighs


33'8"
1st Battery Floor
Floor and Wall Lifted and Wall Forced out by Pressure of Explosion (Prof. Munroe's Theory)
Corr. Iron Side
Windows partly Open
Matched Maple Top Floor
Plank Floor
Gas etc., rising through Cracks between Planks
50th St.
12"15"
Part of Lumber Pile pushed forward by Step and Wheel of derailed Car
Pipes Deflected and broken
Steam, Air and Gas
Lumber Pile about 3' High
ENG. NEWS.
Cross Section.
0' 10' 20' 30' 40' 50'

Cross-Section Showing Probable Path of Gas and Destruction of North Wall.



South Elevation and Plan.

SKETCHES OF TEMPORARY CARPENTER-SHOP UNDER BATTERY HOUSE OF NEW YORK CENTRAL & HUDSON RIVER R. R., NEW YORK CITY.

(As brought out at the Coroner's inquest, the carpenter shop evidently filled with explosive mixture of gas and air, the gas rising through the open joints of the floor. When the room-full of gas exploded, the front wall was blown out and the building wrecked because of the absence of steel columns from this wall.)

about 0.7 as much as air, and therefore will rise in air. That the volume of gas emitted at the leak as previously testified to was sufficient for a mixture of maximum power filling the whole volume of the shop. That the production of a thorough mixture of gas and air was easily brought about under the conditions existing. That men could remain for some time in an explosive mixture of Pintsch gas and air without being overcome or feeling marked effects. That a flame, spark or glowing surface within the range of the explosive mixture, either within or without the building, would ignite the whole, with substantially the same result.

On the question of identifying the accident as a gas explosion, the significant facts were: (1) No localized severe action, such as should have been found had dynamite been the cause, could be found anywhere in the structure; and (2) the effects were uniform through the length of the carpenter shop, and terminated practically at the west end of the shop, indicating a distributed cause coterminous with the shop. Moreover the explosion was accompanied by a flame in the carpenter shop, for two men in the shop, who were hurled respectively south and west a hundred feet or more, had face, hands and clothing burned. This result would be expected if the shop full of gas had exploded.

The state of affairs indicated by the cross-section sketch of the carpenter shop and storage space, herewith, gave easy opportunity for gas from below to rise into the shop. The gas flowing out of the broken pipe in great volumes (the pipe broke in the thread at the end of a coupling, and was torn about halfway across, with maximum opening of about ½-in.; the gas pressure in the system was apparently about 125 lbs. gage at the time of break) would rise up to the top of the storage space. Here it was kept from flowing out freely into the open air at the south by the deep longitudinal plate-girders which support the floor joists of the inclined driveway at the center and the south edge, and thus would have opportunity to percolate through the cracks in the northerly half of the floor, into the carpenter shop. Mixture of gas and air would occur either at outflow from the pipe (especially as compressed air was also escaping) or where rising through the floor cracks, or at both places. The windows of the carpenter shop, which were opened (most of them from below only) during the half-hour of gas leakage, apparently did not greatly affect the process of filling the carpenter shop with explosive mixture, especially as the wind was very light and, being a little south of west, had little influence at these windows. A total leakage of 10,000 cu. ft. af gas, the minimum estimate, would make a volume of 110,000 cu. ft. of 9% mixture, whereas the volume of the shop was only about 70,000 cu. ft.

Some of the floor-joists of the carpenter shop, 12-in. I-beams, were bent downward, and the south line of plate-girders showed some outward bends. Prof. Munroe testified that a pressure of 4½ to 7 lbs. per sq. in. in the carpenter shop would account for this bending. A rather higher pressure, about 9 lbs., is required to account for the destruction by lifting of one panel of the ceiling of the carpenter shop (floor of the lower battery room); this panel had wider beam-spacing than the others, which remained unbroken. A still higher pressure, approximating 20 lbs. per sq. in., will account for the blowing out of the brick north wall. The latter, about 6 ft. high above the granite base course, would be wrecked by outward bending as soon as the internal pressure became great enough to lift the front bay of the building and thus take the weight of the front wall off the lower courses of the wall. A pressure of 20 lbs. would suffice for this lifting The southerly bay could not be lifted, because of the steel columns which tied it down to the floor of the explosion chamber, i. e., the carpenter shop; but at the north side there was nothing to hold the building down against a lifting force which would pivot it about the top of the central line of columns. Prof. Munroe, who made the calculations, figured also on other possible modes of failure of the front wall, but they required higher pressures than that described, and were therefore less probable.

Nothing was learned as to what flame, spark or the like might have ignited the gas.

Besides the question of cause, the responsibility for the accident was inquired into. As to the construction and arrangement of parts at the place of the explosion, Mr. George W. Kittredge, Chief Engineer of the New York Central & Hudson River R. R., gave the opinion that the type of bumping-post used there is the best known. He said also that while the pipe arrangement was designed before 1907 (when he became Chief Engineer), he thought it was the best possible arrangement at this place; locating the pipes in conduits underground would introduce danger of electrolysis, and would make it harder to find and repair leaks; placing them against the north retaining wall, or higher up in the storage space so as to be above train level, or still higher against the south wall of the building, would be objectionable in various ways. He considered these pipes to be well located and amply protected in their actual location.

The District Attorney made much in his questioning of the absence of means for determining at the compressor station the location of a leak on the system; to some extent he dwelt also on the provision of shut-off valves in the gas piping system.

The attorneys for the New York Central brought out no responsibility except on the part of the motorman who ran into the bumping-post. Testimony was introduced tending to show that the air-brakes of the train were in good operative condition, that the motorman had made an emergency application as he neared the bumping-post, and that the wheels had skidded a distance of three car-lengths (or 150 to 200 ft.).

The Coroner's jury did not give an opinion concerning what caused the explosion. They disagreed on responsibility, nine charging deaths to "an unavoidable accident" while three pronounced it the result of "the negligence of the company or companies in charge of the terminal." The motorman who ran into the bumping-post, who had been held by the coroner, was thereupon released from custody.

Annual Meeting of the Kansas Engineering Society.*

This Society held its first annual meeting in the rooms of the Commercial Club of Topeka on Jan. 20 and 21. The program listed 30 papers and addresses but it was not possible to present all that had been planned and allow time for discussion. Great interest has been manifested in the Society since its organization about a year ago, and more than 100 members and visitors were present at this meeting. Although most of the topics discussed were along the line of civil engineering, they were presented in such a way as to be of general interest to other branches of the profession.

At the first evening session of the convention, Governor Stubbs gave a short address. The governor was formerly a contractor and is intimately acquainted with many of the older members. During his talk he spoke of engineers he had known, telling of several incidents that had occurred while he was engaged in engineering work and speaking in particular of several prominent men in the profession as the most worthy citizens of our country. He called attention to several fields of investigation wherein the Society could greatly benefit the State.

For the committee on Paving, Mr. J. Smith, of Emporia, presented a paper entitled "Street Paving." Special attention was called to the expense and unsatisfactory results produced in paving work by the system of requiring a guarantee for a term of years from the contractor. Mr. Smith's plan was to draw up specifications for exactly what was wanted, see to it that the specifications were adhered to and then take the consequences without relying on a guarantee. The advantages of a combined concrete curbing and gutter were shown in this article and a discussion of various fillers for brick paving was also given. Mr. C. M. Buck, of Manhattan, spoke on "Paving Hints."

*Reported by A. R. Losh, Kansas State Agricultural College, Manhattan, Kansas.

Mr. W. H. Jones, of Leavenworth, in a paper on "The Evolution of Highway Bridge Construction and the Advantages and Disadvantages of the Use of Concrete in Highway Bridges," urged the importance of the proportioning and mixing of the aggregates and the placing of the reinforcement. Without first class supervision of the work, concrete was a failure in bridge construction.

The licensing of surveyors was suggested in a paper presented by Mr. J. W. Mavity, of Lincoln. This paper discussed the general inefficiency of many of the so called "surveyors" in Kansas, and treated the subject in such a manner that the only comments and discussion were endorsements. Mr. Mavity outlined a plan to insure to the public the service of a capable surveyor when such was desired. The plan in brief was, that every surveyor should be compelled to place on all maps, plots, plans, estimates and other similar documents prepared by him, and on his business stationery, his name and with it, in characters of equal size, either the words "licensed surveyor" or "not licensed surveyor." The title of "licensed surveyor" should be used only by one who had secured a license through a rigid and practical examination. This article resulted in the adoption of the following resolution by the Society:

Resolved, that the president appoint a committee of three active members of the Society to investigate and consider the question of qualifications for the practice of engineering and surveying within the State of Kansas and to report these findings and recommendations to the Society at its next annual meeting.

For the committee on Railroads, Prof. B. J. Dalton, of Kansas University, read an interesting paper on "The Classification of the Graduation on Railroad Construction." Prof. Dalton gave the specifications for the classifications that are in general use, and discussed them. Mr. J. M. Meade, Engineer of the eastern lines of the Atchison, Topeka & Santa Fe Ry., read a paper on transportation. A paper by Mr. A. C. Titus, of Topeka, on "Early Reminiscences of Railroad Work," aroused much interest.

For the committee on Highways Mr. W. S. Gearhart, of the Kansas State Agricultural College, spoke on "Needed Changes in Our Bridge Law." The laws of Kansas are extremely complicated and decidedly inadequate on bridge contracts. As was presented in this paper, and mentioned several times in the discussion, it is hardly possible that there has been a legal bridge contract let in Kansas in the past ten years. Mr. Gearhart proposed that bridge districts be formed, the same as for road or drainage districts, to give a more equitable distribution of the cost, the assessments to be made according to the benefits accruing. The part borne by the county should be 60% of the cost of the work. Where two or more counties were benefited, 60% of the cost was to be divided among them in proportion to the benefits derived by each.

Prof. W. C. Hoad, of Kansas University, presented a paper on "Stream Pollution and Sewerage." Special mention was made of Kansas streams and the prevailing conditions. Owing to the number of small streams in the state, Professor Hoad advocated the construction of sewage disposal plants in the larger cities. This paper was in the nature of an introduction to reports on investigation work that are to follow. Mr. R. E. McDonnell, of Kansas City, presented a paper on "The Value of Pure Water." This was illustrated by a number of lantern views. Mr. McDonnell spoke of the death rate from typhoid as affected by impure water, and gave some statistics along this line for various cities. The figure for Kansas City was given as 43 per 100,000 as an average for the past ten years.

Mr. N. T. Veatch, of Kansas University, presented a paper on "The State Fish Hatchery at Pratt," giving a full description of the hatchery and its present inadequate system, and discussing plans for improvement. Mr. E. A. F. Reinisch, of Topeka, of the committee on Landscape Engineering, presented a paper on "Tree Planting on Highways." The plans for tree planting on the highways of Kansas were discussed and the practice in European countries was described quite fully.

Mr. Herbert A. Rice, of Kansas University, of the committee on Materials of Construction and Exhibits, spoke on "Some Tests on Concrete Beams." He outlined briefly a series of tests being made at the Kansas University on the effects of repeated loads on concrete beams. A paper by Mr. Herbert S. Tullock, of Leavenworth, on "Foundations" briefly outlined the general methods of foundation construction in bridge work. Mr. R. V. Leeson, of Topeka, spoke on "Needed Legislation," discussing chiefly the laws relating to bridges, highways and surveys.

A paper on "Electric Storage Battery Equipment as an Aid to a Better Power Station Load Factor," was presented by Mr. J. T. Skinner, of Lawrence. Mr. Myron R. Bowerman, of Topeka, read an article on "The Shop System of the Capitol Iron Works."

The result of the election of officers for the ensuing year was as follows: President, Professor W. C. Hoad, Kansas University; vice-president, H. V. Leeson, Topeka; secretary-treasurer, W. S. Gearhart, Kansas State Agricultural College.

City Transportation Problems: A Report by Bion J. Arnold on the Pittsburg Situation.

In Engineering News, Aug. 4, 1910, were reprinted portions of preliminary reports on Pittsburg's transportation problems by Mr. Bion J. Arnold of Chicago. Mr. Arnold was first employed by the Pittsburg Civic Association to study the causes underlying the irregular and inadequate transit facilities there. He was later released by the Civic Association that he might accept a similar commission from the Mayor of Pittsburg. The preliminary report noted showed (1) that the system was "over-expanded," (2) that changes from horse to cable and electric traction had all been capitalized, (3) that dividends had been guaranteed on watered stocks of absorbed companies, (4) that bonds had been floated at high rates and liberal discounts, (5) that there was a lack of depreciation provisions while replacements had been capitalized, (6) that routing was the result of haphazard growth rather than of design; all this until there had been a million dollar deficit in 1910 in addition to poor service. The city and the traction company were advised to get together to rehabilitate the property, to secure new capital for improvements, to provide for depreciation, to reroute the whole system, and to secure adequate service with a fair division of burdens and benefits.

In the letter of transmittal of the final report, now being made public it is stated that an analysis of the earnings, operating expenses, and service of the Pittsburg Railway Co., has been made covering the period since its organization as an operating company for the combined lines, but no attempt has been made to show the detailed corporate history of the inter-relation of the several old companies or the guaranteed rentals and interest burdens. In place of making an appraisal of the properties, to determine whether or not the present fixed charges are excessive and whether or not the service is adequate, the method followed has been to compare the system as operated with its own record and with the records of other systems in metropolitan districts. We have shown below only a few of these comparisons.

Mr. Arnold's recommendations for the Pittsburg District are summarized under four topics (1) immediate surface-railway improvements, (2) future surface-line improvements, (3) future "rapid-transit" developments, (4) legal developments. The complete report is contained in a document of some 200 pages, but the most interesting features are the preliminary discussions and the summary of recommendations for local troubles. We reprint below parts of the first. In our next issue will appear parts of the second, with extracts from the body of the report, showing the relation of local features to the general discussions.

A General Discussion of Transportation Problems.

Pittsburg's traction problem, like those of other cities, cannot be settled now, for all time to come, on account of the increasing demand which will arise from time to time under new conditions; but it has been found in other cities, that an educated public opinion regarding transportation matters has assisted greatly toward adjusting and maintaining the proper relationship between the traction companies and the riding public. It is for the purpose of bringing out a comprehensive statement of the entire problem before analyzing each element in detail, that this general discussion, preceding the other parts of the report, is submitted.

A study of the transit facilities of Pittsburg, as well as of all the larger American cities, shows that while great advances have been made in the art of transportation, much remains to be accomplished. Nearly every city encounters a different traction problem, and many of them are pressing for some immediate solution. In the majority of cases, what is wanted is not only considerable improvement over present conditions, but also a program of development along technical, legal and financial lines which will result in a comprehensive transportation system suitable to meet constantly growing demands.

POINTS OF VIEW.—The term "comprehensive plan" is used so frequently that it may be worth while to define the conditions which such a plan should fulfill. In doing this, it will be discovered at once that there are many points of view, and equally as many opinions as to the relative importance of the elements which enter into the specifications for an ideal system of transportation. In considering the subject, the rights of the patron, the operator, the municipality, the property owner and the financier must each be recognized as well as the requirements for maximum economy.

The Patron of the system believes he has a right to expect adequate service, consisting of plenty of cars provided with cross seats, comfortably heated in cold weather and well ventilated at all times. Every precaution should be adopted for his safety, and after safety and comfort has been secured, the maximum possible speed should be the next consideration. The rolling stock should be noiseless in operation, and the track, special work and car equipment should be built for easy riding. Through riding from point of starting to point of destination is desirable, but if this is not possible, the patron expects universal transfers and one fare for the entire system.

The Operator of the system can secure the best results if the equipment is efficient and up-to-date, if the construction has been sufficiently substantial to reduce maintenance to the most economical point, if the track and paving have been built so as not to encourage vehicles to follow the rail, and if street traffic is so regulated that the surface cars will have the right of way, particularly during the rush hours.

The most favorable conditions for operation exist when the peak loads are not excessive, when there is a large amount of all-day travel, when the flow of traffic is not all one way, so that the cars may be evenly filled in both directions, and when the profit of the short-haul business more than offsets the losses from the long hauls.

The City is best served if the passengers are collected and delivered convenient to places of business; and the system should carry passengers to the outlying districts in the minimum of time and at the lowest cost, so as to reduce the tendency toward congestion in down-town districts. Rapid transit should be provided by well ventilated subways or by means of roads in open cuts, or upon elevated structures designed to present an artistic appearance and to operate with a minimum of noise. Suburban traffic should be handled by electrified terminal systems of the various steam roads so as to avoid smoke and gases.

The street-railway surface system is expected to maintain the paving between and adjacent to its tracks and to sprinkle the streets and reconstruct its roadbed whenever the streets are torn up for changes in grade, alterations in pavement, new sewers or water mains. Free transportation should be supplied to mail carriers, firemen, policemen and other city employees, and special low rates should be made for school children and workmen. Iron poles should be removed upon request and all transmission and feeder cables should be placed underground. In certain cities and in restricted districts of other cities, the underground-conduit system is insisted upon. The franchise should be indeterminate so that "franchise values" will be eliminated, and a system of regulation should be established to insure that the citizens get their full measure of service.

The Real Estate Owner and Promoter often insists upon the best facilities being provided for his immediate district, even at the expense of the remainder of the city. The owner of property in the central part of the city will point out the advantages of confining the growth of the city by restricting non-paying extensions and by charging two or more fares to reach the outlying districts; while the development of the suburban districts and the building up of home communities inside the city limits depends largely upon extensions of rapid-transit facilities and the maintaining of the universal five-cent fare.

Financial requirements will dictate that the rate of fare be sufficient to cover the expense of transportation, maintenance, reserve for depreciation and damages, as well as to pay interest charges and a fair return on the investment. If there be any surplus the excess earnings should be devoted to better service and extensions, or it should be divided with the city in lieu of taxes, franchise payments or other civic burdens.

In considering rates, credit should be allowed for past burdens of non-paying years and for development expenses involved in creating, combining and building up the property and in bringing it to a paying basis. Extraordinary expenses should be amortized and reserves for replacement of equipment, personal damages, fires and other contingencies should be provided.

A broad economical policy requires that the whole transportation system of a district should be controlled as if under one ownership, and that when one system of transportation more efficient than another can be provided, a transfer of passengers should be encouraged from the less to the more efficient system. *Transportation in a city is a natural monopoly; therefore no district should be served with two competing transit systems when one can furnish better service than with the business divided.*

The building of extensions into undeveloped districts should be assisted by assessment on the property benefited, and the operating loss on non-paying lines should be financed so as not to be too heavy a burden upon the remainder of the system. As districts develop, the improvement of transit facilities should be somewhat in advance of the actual requirements.

EQUITABLE BALANCE.—The problem, therefore, is how to find an equitable balance between all these conditions. There is to be provided a maximum of safety, comfort, speed and capacity. Pavements are to be repaired, taxes are to be paid and all equipment must be thoroughly maintained and a reserve fund accumulated so as to keep the property abreast of all advances in the art. Separate systems must be controlled or combined to avoid wasteful competition and to secure the efficiency of one management. Extensions must be made into promising territory. Rapid-transit systems should be provided for and built in advance of immediate needs, and the losses during the first years of operation must be financed. If private capital is to be attracted for building transit systems, a return on the investment somewhat larger than current rates of interest should be allowed.

There are so many elements arising from local conditions that it is quite impracticable to develop a formula that would be universally applicable and while comparisons between different cities are instructive, the solution of any one problem must be preceded by a study of the relative importance of its elements as determined by the special requirements of the given locality. In each case it is desirable to determine what constitutes a fair requirement of the following items:

(1) Original investment, (2) legal, technical and financial development expenses, (3) working capital, (4) adequate service, (5) probable income, (6) operating and maintenance expenses, (7) taxes and franchise payments, (8) reserve funds for insurance, damages and depreciation, (9) rate of return on actual investment, (10) provision for future improvements and extensions, (11) facilities for rapid transit.

Transit facilities may be called the blood vessels of the city or district, and it is only by providing for unrestricted flow of traffic from any one district to every other district that we have the most favorable conditions for strength and growth. Hamper this free intercourse by poor transit facilities; at once there is an arrested development. On the other hand, if facilities are extended too far and too fast, there follows a dissipation of strength. What is always wanted is an equitable balance, and a constructive program which will maintain this balance.

PRESENT TENDENCIES.—It may be of benefit to indicate briefly the present tendencies which are more or less marked in the movement for transit betterments. There is a decided tendency, for instance, toward *recognizing the actual investment required to provide adequate service.* This tendency is shown by the valuations of traction properties which are now under way by various authorities and by the studies that are being made by engineers to determine not only the first cost and the "cost to reproduce" certain properties, but also the probable additional expenses which have been involved in building up the property and securing a good business. It is hard to see how the problems of reorganization and of rate making can be fairly handled without making a fair determination of the reproduction cost, and in some cases, of the depreciated or present value.

There appears to be a constantly growing sentiment *in favor of building extensions into new territory by means of assessment;* that is, charging the property benefited with at least the cost of the permanent way. This method of financing branch lines which will be operated at a loss for some time, has been worked out in Berlin in connection with the underground road, and petitions are now being signed in certain districts of New York which are likely to result in its adoption in this country.

There is also a gradual tendency *toward a higher standard of service.* Better lighted, better heated and more comfortable cars are in demand and limiting the crowding allowed is resulting in more adequate service

While it is generally recognized in this country that a seat for every passenger is impracticable during the rush hours, knowledge of the fact that such a policy is possible in foreign cities seems to justify the more insistent demands for more seats here at the time passengers wish to travel.

FARES.—There has been some demand for three cent fares, especially in the Middle West, and experiments are now being made to determine the possibility of this fare. The results, however, are tending to prove that cheap fares and good service cannot be secured at the same time which points to the conclusion that, as a rule, if the rider wants good service he must be willing to pay reasonably for it.

On the other hand, the movement to raise the city fare above the 5-ct. limit has received little encouragement; and there seems to be no decided sentiment in this country in favor of the European zone system. It appears that *a concerted effort must be made to work out our transit problems on the basis of a single 5-ct. fare for a ride in one general direction.* And it will probably only be when failure to do this, due to excessive length of average haul, has been demonstrated, that it will be advisable to consider raising the fare above 5 cts. Then it will probably come in the form of making a small charge for certain transfers. In other words, of all the possible solutions, the augmenting of income by charging more than 5 cts. for a ride within the city limits would appear to be one of the last suggestions to be considered.

An effort has been made elsewhere to increase income by *abolishing free transfers* but there is a question as to the benefits to be derived from such a course. *The abuse of the transfer privilege should rather be eliminated; its intelligent use always has been a logical and economical method of handling and increasing traffic.* The tendency should be toward one comprehensive system with consistent transfer facilities between the different branches. If the collection and distribution of passengers can be accomplished more conveniently and economically by means of the transfer than by means of the "direct" system, which often means the duplication of service, then the transfer system should have the preference.

When it is understood that the operating expenses per car mile are from three-quarters to one-half as much per car for a subway or an elevated structure as upon the street surface, and that at the same time the subway or elevated car runs at fully double the speed and carries at least 50% more seats, it will be seen that, as far as operating expenses are concerned, rapid transit subway and elevated lines have a great advantage. The problem is to secure sufficient business to run enough car miles over the more expensive structure so that the fixed charges per car mile will not be excessive. As a rule, any subway or elevated system will not prove financially successful in which the car miles run during any year are not equal in amount to at least half the investment in dollars then in the property (that is, an investment of two dollars for each car mile on a yearly basis). Experience is gradually showing us that there are economical limits—both high and low—between which a certain density of traffic will justify a corresponding transportation system; beyond these limits some other system should be provided. For instance, in Boston, when the surface system became congested with traffic in the down town districts, it was found more economical to handle passengers on an elevated structure. In the course of time, as traffic increased, it was found desirable to extend the limits of the elevated road zone and to use subways. The same conclusions are being reached in Brooklyn, where as in Boston, the elevated and surface roads are both under one management. In other words, a unit system of construction is naturally being developed together with a zone system of operation rather than a zone system of fares. But this is only possible when the entire transportation system is practically under one control.

SHORT HAUL AND DENSITY.—The fact that the operating expense per car mile of the surface lines is greater than the cost per car mile through a subway or on an elevated line, naturally leads to a more serious study of the possible economies in surface-line operation. Progress in this direction shows a decided movement to reduce the relative weight of the car per seat, resulting in lower power costs and less annual cost for maintenance of roadway. At the same time, the income is being increased and conserved by the introduction of improved fare collecting systems. *There remains to be devised, however, some system of operation on the surface lines for the handling of short haul passengers in short haul cars.* There is a large profit in all of our cities from the short-haul business. But as a rule, it is now being handled in cars which run practically to the ends of the various lines, so that much of the advantage of the short-haul profits is offset by the expense of operating cars with empty seats in the outlying districts.

It must be recognized that there are two things which reduce the cost of transportation per passenger—one is *density of traffic* and the other, *short haul.* In Paris, the subway system is a paying investment, because the average haul is less than two miles and the cars are operated over comparatively short lines. Universal free transfers are provided over the entire system, but the lines are not physically connected, and the longest haul is handled by trains running only six miles, at the end of which distance, they are looped back. On the other hand, the present subway in New York furnishes a continuous ride of 17½ miles for one fare, while the average passenger travel is about five miles. Taking into consideration the relative purchasing value of money in New York and in Paris, a comparison of the two cities shows that in the Paris subway, the fare is equivalent to 4 cts. for an average ride of two miles, or at the rate of 2 cts. per mile, while in New York, the fare is 5 cts. for an average ride of 5 miles, or at the rate of 1 ct. per mile. On a mile basis, therefore, New York gets its subway transportation at half the Paris rate, but the New Yorker travels more than twice as far on each ride as the Parisian, so that the average fare per passenger is greater in New York than in Paris. New York has the advantage of density of traffic; Paris has the advantage of short haul. New York should cultivate the short-haul business in short-haul cars as is done in Paris and enjoy the benefits of both elements—short haul and density of traffic—and thus be relieved of the present uncomfortable overcrowding in the short-haul district which now seems to be necessary in order to secure the very long rides for a universal 5-ct. fare.

TAXES.—The question of taxation is being more carefully studied, and it is being recognized by some students of transportation problems, that perhaps the railroads have been called upon to carry more than their share of the tax burden. For a time, the only apparent method available for the people to get their share of the profits, often imaginary, derived from the railway business, was by means of taxes. Hence special taxes of various kinds were devised. But as logical methods of control and regulation are being introduced and as the records of investment, earnings and operating expenses are being more intelligently studied, this fact is becoming apparent—that there is very little surplus left for taxes, (particularly for the payment of a franchise tax), if a company is to furnish adequate service, properly maintain its property, provide for depreciation due to renewals and obsolescence and pay even a moderate return on the investment so that needed extensions may be financed.

As legislatures can establish Commissions which have power to regulate service, control operation and fix rates, there apparently is nothing left, under such conditions, of what has been termed "franchise value." In fact the term "indeterminate franchise" implies this very feature. Now if there is no franchise value, there should be no tax upon it. The burden of maintaining paving is an inheritance from horse car days, when the horses used in hauling the street cars, actually wore out the pavements between the rails. And there is justly a growing sentiment toward the removal of this burden, providing, of course, that the money saved to the railway company is diverted to furnishing better service or toward offsetting some of the other legitimate expense of transportation.

DEPRECIATION.—There is much discussion as to setting aside each year out of earnings, some definite amount to offset the depreciation of the property due to obsolescence and other causes; and it is generally conceded that *this is a duty and a necessity that no longer can be neglected.* What should be done with the past obligations of this nature which have accumulated through years of development of poor business, is a problem which is receiving much consideration, but there hardly have been sufficient decisions reached to outline a final conclusion or even to indicate a decided tendency.

RATE OF RETURN.—It is certain, however, that as all these requirements of successful and growing transportation systems are being more thoroughly analyzed and understood, that there is being developed a conclusion that the profits from the transportation business are, as a rule, no longer excessive; and the removal of the idea that a franchise for a street railroad in a center of population is "as good as a gold mine" is having a good effect toward reaching a sane solution of transportation difficulties. Money actually used to produce a property should be assured a fair rate of interest, and if private capital is to be attracted, an additional profit over current interest rates must usually be allowed varying in proportion with the hazard of the enterprise. It must be admitted, however, that under conditions where the enterprise has become established, the fair rate of return considered necessary is approaching nearer and nearer toward just the interest charge at current rates; and the surplus earnings are being called upon to satisfy the demands for extensions, for effective maintenance and for reserve to cover depreciation.

The rate of interest is being reduced in some places by raising money for rapid transit systems by means of city credit, but in these cases, the furnishing of the money required for equipment and for the operation of the system has been left to private capital. In other cases, as in Chicago, the actual investment in the surface street railway system has been determined by appraisal and an exact accounting has been made of the expenditures for rehabilitation, betterments and extensions. Thus in Chicago on the total investment, there has been allowed a return of 5%, plus a share of the profits, amounting to 45% of the net earnings, the other 55% going to the city. In other cities where the relation between the investment and the return has not been so carefully determined, there is a tendency either to force a reduction of the rate of fare or else an increase in service rendered.

It also must be recognized that if some method were available to absolutely keep the operation of the road "out of politics," there would be a decided tendency in some cities toward municipal ownership and municipal operation.

RECAPITULATION.—It will be seen from the foregoing that any attempt to formulate decisions of a hasty or prejudicial nature would very likely fall far from the truth and that a coherent solution of the problem requires analysis from many viewpoints and by various minds.

The Patron should learn to recognize that empty seats cost as much to operate as occupied seats, that a seat for every passenger during the rush hours must mean the curtailment of the service during the non-rush hours, and that new cars and new tracks cannot be furnished until old equipment has been in service a reasonable length of time.

The Operator should adopt the policy of continually trying to please the public and should arrange his schedules and routes to accommodate the greatest number. If the best service can be rendered by establishing through routes and giving transfers, these methods should be adopted in an effort to increase gross earnings by making it easy to ride. It should be realized that publicity of intention and results is the best policy.

The City should co-operate with the company on street traffic regulation, widening the streets where necessary and issuing permits for extensions and new connections which are absolutely necessary for the best routing system. Unnecessary taxes and the burden of paving maintenance should be removed so as to allow more money for betterment of service.

The Property Owner should recognize that the general prosperity of the entire district is not only vital to him but to others, and that routes and extensions cannot be controlled for his particular benefit.

The Financier must realize that the day for exploitation of established public enterprises has passed, and that the fixed charges on such properties must be reduced to a fair return on the actual investment. New capital which is absolutely necessary for the continued life and usefulness of any public utility must be furnished, and this flow of new blood should be supplied in advance of actual needs, if it is to have a strengthening influence on the system.

Economy and a continuation of an equitable balance dictates efficient management, and the setting aside out of earnings each year, of a fund to provide for renewals.

Transportation in the Pittsburg District.

Pittsburg owes much to transportation, and transportation to Pittsburg. Its growth from the original Fort Pitt into a fortified trading post and later into an outfitting village was due to its location at the confluence of the Monongahela and Allegheny Rivers, forming the headwaters of the Ohio River, which early became the main highway between the Atlantic seaboard and the great West and Southwest.

While, during these developments, Pittsburg has been calling for and receiving the best that the art of transportation has had to offer, it has not been slow in contributing in large measure to progress in this line. It was among the first of the American cities to introduce the horse car and the cable system and was a real pioneer in building electric street railways. The genius and industry of its workers has made Pittsburg the home of the steel rail, the block signal, the air brake, the steel car wheel, the all-metal car, the electric motor and the steam turbine. Thus, while Pittsburg owes much to transportation, it has paid its debts with interest and has a right to expect much of future transit developments.

THE PITTSBURG DISTRICT.—Pittsburg is really not a city, but a district, and while there are "city limits" the study of the local transportation problem cannot be confined to these limits. Of the 581 miles of track comprising the present system of the Pittsburg Railways Co., there are 260 miles located inside the city limits, the remainder of the trackage serving the surrounding boroughs and reaching out as interurban lines as far south as Washington and Charlerol.

Of the million people served by this system, only about one-half are to be found within the city proper. The Pittsburg Railways Co. makes no distinction in its accounting system between earnings and operating expenses inside and outside the city limits, which is another reason for considering the Pittsburg District as a whole, rather than attempting to analyze the traction situation of the city only.

It will be found imperative, eventually, to handle the problems of water, sewage and other public utilities as a district rather than as a city, and as the pros-

perity and growth of any one locality has an influence upon the entire community, there should be no distinction made in favoring the transportation developments in any certain direction.

The system of the Pittsburg Railways Co. serves the entire district. There are small competing street-car systems in some of the boroughs, such as Homestead and McKeesport, but nearly the entire population of the district depends for street-car service upon the Pittsburg Railways Co.

The striking feature of the locality, from a transportation standpoint, is the scattered way in which the district has been settled. The entire city and the surrounding towns have simply "grown up" but not according to any definite or pre-conceived plan. Starting with the district lying between the rivers near their junctions commonly known as "The Point," industrial enterprise has spread out the workshops and the workers along the rivers and railroads, while the homeseeking spirit has carried the resident population up to the hill tops in an effort to get away from the smoke that has been inseparable from the city's progress toward its present greatness.

The effort to secure favorable transportation facilities has been the fundamental cause for the division of the district into somewhat isolated centers. Manufacturing necessities early preempted the few available level factory and mill sites along the river banks or in the valleys contiguous to the railroads. The houses of the workmen were perched on the hill sides or were clustered in the ravines nearby, and "The Point" became the natural administrative and commercial center of the district.

Isolated home communities sprung up along the lines of the steam railroads and small trade centers developed at these points to serve the residents. During the time that the district depended for intercommunication upon the steam railroads, the relatively infrequent service caused each locality to be more or less isolated, depending upon itself for its own amusement and supplies, but with the introduction of the trolley system, the various communities were brought more closely together and the settlement of intervening territory began.

It was probably no philanthropic motive which prompted the promoters to build trolley lines to connect these outlying boroughs with each other and with the larger city, but the fact remains that very often the communities served by these pioneer lines have gained much more indirectly than they have contributed to the railroad in return. Bridges were built, grades reduced, highways opened up and streets were paved by the railroad system far in advance of the actual requirements of many localities, and the reward for some of this enterprise is still lacking.

Fig. 1 is a photographic reproduction of a model showing both the location and elevation of the various routes comprising the street railway tracks of the Pittsburg Railway Co. The map is laid out on a horizontal scale of 2,000 ft. to the inch, and the elevations on a vertical scale of 200 ft. to the inch (measured above normal river level). From this photograph the elevations can only be judged in perspective. It will, however, be apparent at a glance that transportation over the streets of Pittsburg is accomplished with unusual difficulties. As the great majority of passenger traffic centers in the low lying "Point District," nearly every line reaching the suburbs is obliged to ascend heavy grades, with the exception of the Second Avenue line to Homestead, the Penn Ave. and Butler St. line to Aspinwall, and the West Carson St. line to McKees Rocks. Pittsburg's most direct line to the East End—via Center Ave.—is handicapped by one of the worst hills, likewise the Federal St.-Perrysville Ave. line to Riverview Park district. The low level tunnel under Mt. Washington has evidently been of the greatest benefit in reaching the South Hills suburban district and providing convenient interurban connections to the towns south of Pittsburg.

The Pittsburg District has already been very completely covered by its local transportation system, now the building up of the vacant spaces must take place. This can best be accomplished by limiting further advancement into outlying territory to actual necessities and by furnishing better service over the tracks already provided.

What is needed in the Pittsburg District at the present time is a "get together" movement. The division lines between the different parts of the district must be more completely eliminated and the various centers must grow out to meet one another, and become massed into one community. In bringing about this desirable result, the lines of the local surface transportation system will play the most important part.

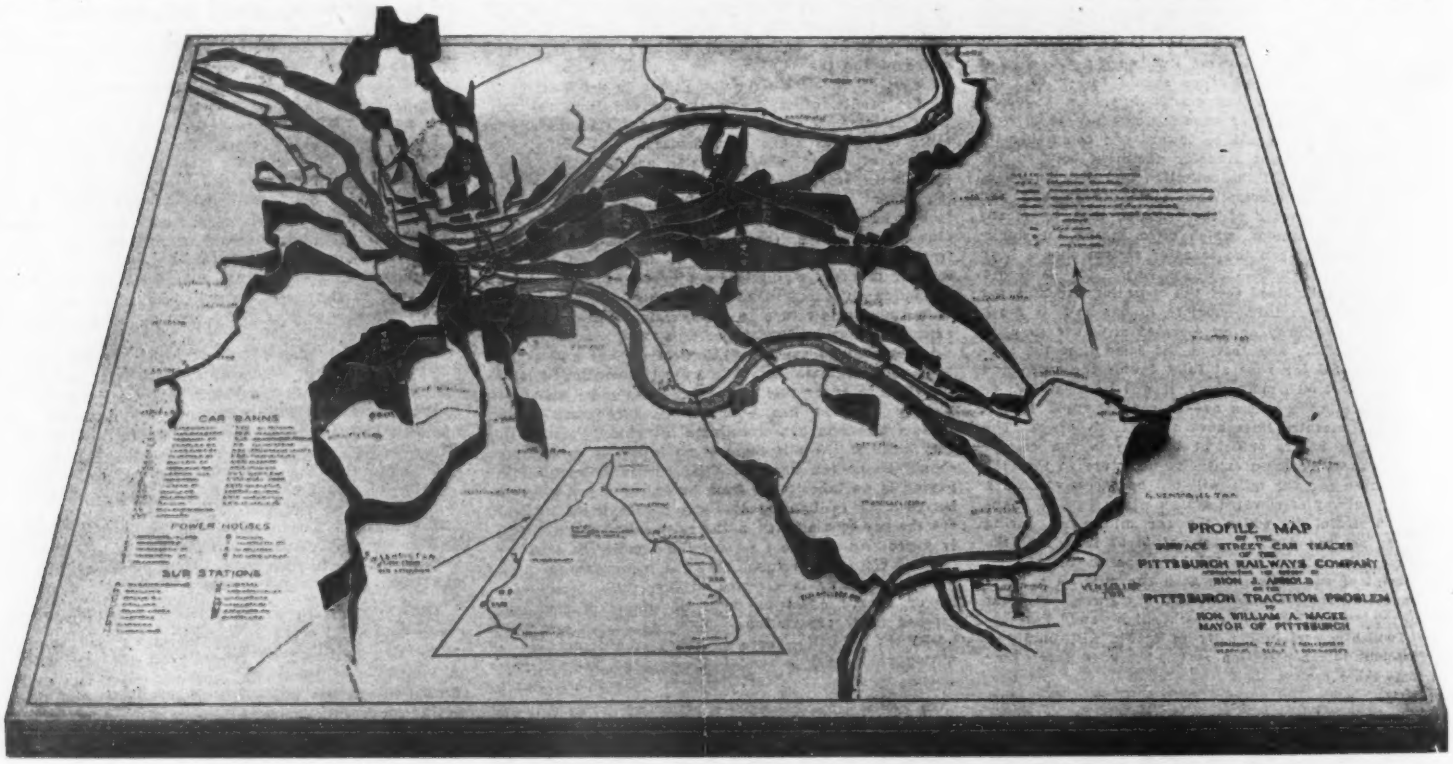


FIG. 1. A RELIEF MAP OF THE STREET-RAILWAY SYSTEM OF THE PITTSBURG DISTRICT.

DIFFICULTIES AND ADVANTAGES.—It has often been pointed out that the rugged topography, consisting of steep hills, deep ravines and only a few level spots, the narrow streets, the concentration of business into a section of 300 acres, the division of the city by its rivers into three parts, the isolated outlying communities and the lack of continuous street systems, are a unique combination of disadvantages which make it difficult to secure ideal or even good transportation. However, it is very possible that a little study may turn many of these disadvantages into benefits. For instance, the fact that the city grew up without a definite plan resulted in many "cross cut" thoroughfares between the different centers. This is really an advantage over those cities having a right angle street plan without diagonal avenues. The development of the district, primarily by local communities, will be a distinct benefit to traction developments in the future, as the scattering of the shopping and amusement districts throughout a city means considerable short haul traffic, which will get on and off the through cars, thus utilizing them in the most profitable way. The more passengers that may be accommodated by each seat on a single one-way trip, the more efficient is the use of each car, and to secure this result, the more centers existing to attract riders, whether for business or pleasure, the better the service that may be given with the same equipment.

The fact that it is impracticable to run large cars up into the hills, where narrow and crooked streets with excessive grades exist, may be turned to good account toward securing better service by allowing this disadvantage to dictate the use of a transfer system, using the small hill climbers on through routes from one hill section to another, connecting by means of a convenient transfer station to the main line of larger cars, which will carry passengers, through the business district to other transfer centers on opposite sides of the city. A similar transfer system has been worked out in Boston with notable success.

The entire situation, therefore, is by no means hopeless and does not demand radical changes in design or method of operation. A transportation system should really keep ahead of the development of the district which it serves, and fortunately the records of other cities show that increased business follows immediately after improved facilities.

ONE DISTRICT, ONE SYSTEM.—The most striking feature of the transportation developments in the Pittsburg District is that its surface electric railway utilities have been combined into one system. Unification of operation is a result which may or may not be an advantage. At the present time there are some points of disadvantage, resulting largely from the fact that the future of the system was too heavily capitalized at the time the combinations were made.

There can be little doubt as to the many benefits to be secured by the operation under one management of a large system such as is now controlled by the Pittsburg Railways Company, but unless the public gets some of the advantages of the combination, there can accrue to the system itself no lasting benefits. The interests of the District and of the company are so inseparable that eventually the sentiment must prevail that the benefits should be divided share and share alike.

Every effort should be put forth to conserve the progress that has been made toward a combined District served by a single trolley system, but this will be impossible if the company endeavors to collect toll too far in advance or if the citizens of the District fail to recognize that the building up of the system has required faith, enterprise and a large investment which in course of time should have its reward.

(To be concluded in the issue of Feb. 16.)

MASSACHUSETTS RAILWAYS were operated for a smaller percentage of their receipts in 1910 than in any year for a decade, as shown by the following table in the annual report of the State Railroad Commission:

Years.	Total Operating Revenues. (1 = 1,000)	Operating Expenses. (1 = 1,000)	Percentage of Expenses to Revenues.	Net Revenue from Operation. (1 = 1,000)
1901.....	$82,385	$57,293	69.54	$25,091
1902.....	86,920	61,355	70.59	25,564
1903.....	93,325	67,774	72.62	25,551
1904.....	95,280	69,145	72.57	26,135
1905.....	98,899	71,393	72.19	27,505
1906.....	105,954	73,885	69.73	32,068
1907.....	111,433	80,912	72.61	30,521
1908.....	106,309	80,956	76.15	25,352
1909.....	108,105	75,049	69.42	33,056
1910.....	120,140	82,067	68.31	38,073

Annual Meeting of the Ohio Engineering Society.*

The 32d annual meeting of the Ohio Engineering Society was held in Columbus, Ohio, Jan. 24-26. Although the attendance was slightly below the average, the Secretary-Treasurer reported a considerable increase of the enrolled membership and a sound financial condition. The address of welcome to the city was made by the Director of Public Service, H. S. Holton, himself an engineer. President E. G. Bradbury pointed out in his address some of the causes for the existing unsatisfactory conditions in the engineering profession. He called attention to the frequency with which engineers permit themselves to be handicapped by an insufficient force and to the evils of price competition in the practice of engineering.

The convention devoted much time to the discussion of the proposed bill, recently introduced in the Ohio State Legislature, providing for the registration and examination of civil and mining engineers and surveyors. A resolution endorsing the proposed bill was adopted as follows:

Whereas, the conditions surrounding the practice of civil and mining engineering and surveying in the State of Ohio are such that inexperienced, incompetent, or dishonest persons may and do maintain places of business for the practice of the aforesaid professions and, further, may and do impose upon the public with inaccurate, ignorant and dishonest work, thereby discrediting the entire profession of civil and mining engineering and surveying and causing to the public much inconvenience and loss, and,

Whereas, a bill providing for the creation of a State Board of Registration and Examination for civil and mining engineers and surveyors and for the issuance of certificates to competent persons entitling them to practice such professions is about to be introduced into the General Assembly of the State of Ohio, now therefore

Be It Resolved, by the Ohio Engineering Society in convention assembled, that we endorse such measure and respectfully urge its passage, and that a copy of this resolution be transmitted by the Secretary to such committees of the General Assembly as the above-mentioned bill may be referred to.

Another resolution adopted concerned the employment of consulting engineers on municipal work performed under the direction of the regularly employed engineer:

Whereas, in the conduct of municipal affairs, it becomes frequently desirable to employ the services of expert engineers in consultation with the regularly employed engineer of the municipality, or for the performance of work for which the office of such regularly employed engineer is not required, and

Whereas, it has been brought to the attention of this Society that such expert or consulting engineer is frequently employed by city officials without regard to the wishes of the regularly employed city engineer, and

Whereas, such condition is contrary to professional courtesy and ethics and to the universal practice among other professions and tends to create discord and an undesirable relationship among the members of our profession, now, therefore

Be It Resolved, by the Ohio Engineering Society in convention assembled, that it is the sense of this society that the employment of any expert or consulting engineer by any municipality having a regularly employed engineer should be only undertaken on recommendation of such regularly employed engineer, and that the selection of such consultant or expert should be by him; and that the committee on legislation be instructed to consider the feasibility of preparing and introducing such measures before the General Assembly of the State of Ohio as will render the procedure herein outlined mandatory upon the officials of any municipality within the State.

[It is of interest in connection with the above resolution to recall that there was some discussion along the same line at the recent annual meeting of the Canadian Society of Civil Engineers at Winnipeg, where the discussion centered about a specific case of friction between the city engineer of Vancouver and a consulting engineer appointed by Mayor Taylor of that city.—Ed.]

The construction of bituminous macadam roads was treated at length in a paper read by Mr. James T. Voshell, Assistant Engineer of the Office of Public Roads, U. S. Department of Agriculture. A paper on the maintenance and repair of macadam roads was presented by Mr. D. W. Seitz, Assistant State Highway Commissioner. Mr. W. P. Blair, Secretary of the National Paving Brick Manufacturers' Association, presented a paper on "The Manufacture of Paving Brick and Their Use in Street and Road Construction."

The road laws of Ohio were reviewed by Mr. J. C. Wonders, State Highway Commissioner, who outlined also proposed legislation affecting township and county roads. The proposed bill was one prepared by Mr. Wonders under instructions from the State Legislature and was soon to be introduced. This bill placed the location of roads in the hands of the county surveyor, while the care of all completed township roads was entrusted to a highway superintendent. The post of highway superintendent was made an elective office. Maintenance of the county roads was entrusted to the county surveyor, who was also required to supervise the work of the several highway superintendents within his county. The Society adopted a resolution endorsing this bill and urging its enactment by the Legislature.

A through-arch concrete bridge, with concrete floor-slab supported on transverse reinforced girders hung from two reinforced, hingeless arches, was described in a paper by Mr. E. A. Gast. In this bridge the arch thrust is taken up by tension steel in the floor slab, thus relieving the abutments. The span is 73 ft. with 31-ft. roadway and 50-ft. width over all. The bridge was designed to carry two 40-ton traction cars. In its construction, recently completed near Cincinnati, Ohio, the floor and haunches were built on falsework and the arches constructed last.

A symposium of the operation of sewage purification works was presented by Mr. Paul Hansen, State Sanitary Engineer of Kentucky, Mr. Wm. H. Dittoe and Mr. R. W. Ferris, Assistant Engineers of the Ohio State Board of Health. Mr. Hansen's paper dealt with general considerations, urging the employment of competent men, the keeping of complete records, the use of measuring devices and the need of careful attention to neatness and appearance. Mr. Dittoe's paper discussed in detail the operation of sedimentation tanks and sprinkler nozzles in small sprinkling filter plants. Mr. Ferris explained the operation of the intermittent sand filter and contact bed.

"The Province of Disinfection" was the title of a paper presented by Mr. Clyde Potts, of New York City. Mr. Potts preferred the use of sodium hypochlorite to that of calcium hypochlorite for the disinfection of water supplies. He believed, however, that chloride of lime at $30 per ton was cheaper than sodium hypochlorite unless electric current could be obtained for under 1 ct. per KW.-hr. He recommended the use of the hypochlorites as an emergency measure in case of epidemic, and in small proportions for the treatment of filtered water, to avoid the need for overdosing with alum.

Mr. Philip Burgess, of Columbus, Ohio, read a paper entitled "Some Features of the Design of Infiltration Plants." He called attention to the fact that water drawn from sand or gravel deposits beneath the bed of a river may frequently prove to be ground water flowing to the river rather than filtered water. He outlined the preliminary examinations and the tests necessary for a plant of this type. Where a permanent supply can be thus obtained, Mr. Burgess considered infiltration plants both satisfactory and economical, provided that disinfection be resorted to, when required, to assure proper bacteriological results.

Among those who participated in the active discussion of the papers on sewage disposal and water-supply were A. Elliot Kimberly, Wm. R. Copeland, Paul Hansen and C. E. Sherman.

Other papers presented were an illustrated description of famous bridges of history, by W. J. Watson, of Cleveland; a paper describing the methods of coal mining in Mexico, the character and habits of the people and a Mexican bullfight, by Andrew Roy, former State Superintendent of Mining of Ohio; and a paper on a new type of iron forms for concrete building construction, by C. E. Bushey, of Mansfield, Ohio. Prof. C. E. Sherman, of Ohio State University, described the methods used by the U. S. Geological Survey in determining the area of Ohio. He announced the correct area to be 41,240 square miles, exclusive of water surface in Lake Erie and its estuaries. [Statistics now on record give 40,740 square miles.—Ed.] The area of inland lakes was given as 50 square miles. The figures given are for the area projected on sea level.

A resolution was adopted making provision for an attempt to affiliate with the Ohio Engineering Society the various local engineering organizations of the State.

Officers for the ensuing year were elected as follows: President, Hugh K. Lindsay, Columbus; Vice-President, Frank R. Landor, Cleveland; Secretary-Treasurer, C. J. Knisely, New Philadelphia. Board of Trustees: P. P. Evans, Cleveland; J. M. Harper, Cincinnati; F. W. Jennings, Columbus; D. W. Seitz, Columbus; C. E. Bushey, Mansfield.

*From information supplied by E. G. Bradbury, ex-President of the Society, 605 Hayden Bldg., Columbus, Ohio.

Notes from Engineering Schools.

CORNELL UNIVERSITY.—It has been announced that a gift of $50,000 has been made by Mrs. F. O. R. Lang, of Montclair, N. J., for the construction of new workshops for the Sibley College of Mechanical Engineering. Construction will begin this spring and the building will be completed by fall. The gift was made in memory of Mrs. Lang's father, Jasper R. Rand, her uncle, Addison C. Rand, and her brother, Jasper R. Rand, 2d, all identified with the Rand Drill Co., which was consolidated some years ago with the Ingersoll-Sargeant Drill Co. Mr. Jasper R. Rand, 2d, was Vice-President of The Ingersoll-Rand Co. after the consolidation and until his recent death.

LEHIGH UNIVERSITY.—It is reported that a series of tests of the strength of mine supports is being made in the John Fritz Laboratory in connection with the studies which the Scranton commission is making on cave-ins at that place. The Delaware, Lackawanna and Western Coal Co. has sent to the laboratory from the National colliery, a carload of materials, of which mine props are ordinarily made—ties, timbers, sandstone, fire clay, bone coal, broken stone, sand, culm, etc. These will be used so as to cover all common forms of support. A report on the results of the tests is expected in a couple of months.

UNIVERSITY OF MICHIGAN.—More than 1,000 alumni were present at the national dinner at the Hotel Astor, New York City, Feb. 4. The engineering department was well represented. Dr. Royal S. Copeland, President of the New York Alumni Association, introduced the toastmaster, Mr. Earl D. Babst, of New York City, who was given the chief credit for the conception and organization of the dinner. Among those who spoke were President Harry B. Hutchins, Justice Wm. R. Day ('70) of the U. S. Supreme Court, U. S. Senator Geo. S. Sutherland ('83) of Utah, U. S. Representative James F. Burke ('92) of Pennsylvania, Governor Chase S. Osborn of Michigan, and President-Emeritus James B. Angell. The illusion of an old time Ann Arbor mass meeting was completed by the presence of Prof. Stanley to lead the singing and Prof. Trueblood as yell-master.

UNIVERSITY OF NEBRASKA.—The new Mechanical Engineering Laboratories of the University of Nebraska were dedicated on Jan. 18 In the morning addresses were given by Messrs. J. A. L. Waddell of Kansas City, B. J. Arnold of Chicago and M. E. Cooley, Dean of the College of Engineering, University of Michigan. At a luncheon following these addresses, three $1,000 scholarships were presented to the College of Engineering by Mr. John R. Webster, President of the Omaha Bridge & Terminal Co.; Mr. William G. Whitmore, Regent of the University of Nebraska, and Dr. J. A. L. Waddell.

The formal exercises were held in the evening, and included brief addresses by Hon. C. S. Allen, President of the Board of Regents, Dr. Samuel Avery, Chancellor of the University, and Dr. W. F. M. Goss, Dean of the College of Engineering,

University of Illinois. The formal address of the meeting was delivered by Dr. Goss on "The College of Engineering as a Feature in General Education." At the conclusion of the address the honorary degree of Doctor of Engineering was conferred on Prof. Cooley, Dr. Arnold and Dr. Waddell.

The new Mechanical Engineering Building has been recently completed at a cost of $118,000. Its over-all dimensions are 195 × 160 ft. It is built in a modified Roman Doric style of architecture, the materials being brown iron-spot pressed brick with terra-cotta trimmings. In addition to class-rooms and offices of the department, the building contains the power and fuel-testing laboratories and the foundry, forging, machine-tool and woodworking shops. The equipment has a value of about $70,000.

The Fire Loss and How it Can be Reduced.*

By W. H. MERRILL.†

America's fire waste averages $250,000,000 per year for the last five years, being a loss of about $30,000 for each hour. The loss per capita in America is approximately eight times as great as the average per capita loss in European countries.

Each loss by fire is a drain upon the material resources of the country, irrecoverable through collection of insurance. For that which the individual destroys by fire, under insurance taxation, the nation must pay.

An inquest after every fire, and laws penalizing carelessness resulting in fire losses, have been suggested, and these would be serviceable. They would do more than penalize—they would teach. They would instruct the man on the jury as well as the prisoner. And they would also instruct the people generally who have been accustomed to extend sympathy rather than criticism towards the individual who permits his property to burn.

Instruction on fire hazards given to children at schools would tend to relieve the next generation of much of the shame attached to ours. Fire marshal laws are well administered in many of the States. Proper building laws and suitable ordinances governing explosives and combustibles are enforced in some of the cities.

Insurance companies are lending their aid in a united effort to reduce the fire waste and prevent conflagrations, for otherwise they cannot do a safe business at popular prices. The Credit Men's Associations throughout the country are interesting themselves in the matter, realizing that a dependable insurance is necessary to a sound credit.

The National Board of Fire Underwriters has prepared a model building code, which it distributes freely to officers of all municipalities who can be interested. It employs expert fire protection engineers who visit all of the principal cities of the country and make extensive reports on conflagration conditions. In Chicago it has built laboratories where tests are made and reports issued on various devices, materials, systems and appliances having a bearing on the fire hazard. This institution, the Underwriters' Laboratories, has erected and occupies what is generally believed to be the best model of fireproof building construction in America, and up to the present time over 5,000 reports on various subjects and appliances coming before it have been promulgated. The findings of these reports are generally accepted by the authorities throughout the United States and Canada.

The Laboratories have inaugurated a system of inspection at factories turning out fire appliances, and attach to the goods themselves their manifest of approval whereby the appliances best suited for use can be readily recognized wherever found. At the present time the Laboratories are labeling at the rate of 20,000,000 devices, materials and appliances per year.

The Laboratories' labeling system is ideal in that the people who do the certifying have a financial interest, presumably equivalent to that of the purchaser, in the ability of the labeled article to properly perform its designed functions.

I will cite a few instances where a system of this kind would prove serviceable: Seven years ago a man put ten cents worth of baking soda in a five-cent tin tube. He sold it for three dollars as a fire extinguisher to use in the stage of the chamber of the Iroquois Theatre in Chicago. At a Christmas pantomime this great chamber was hung with flimsy draperies representing fairyland. One of these draperies was ignited by a spark from an electric lamp representing a moon. The operator testified that the fire in its incipiency could have easily been extinguished by a small stream of water, but the unreal extinguisher being at hand, he waved it as directed, expecting the magic wand to be effective in such surroundings. Unfortunately, there was nothing "make-believe" about the fire, and the result was and always will be very real to the families and the friends of over 600 women and children, whose lives were sacrified that a man might make a profit of two dollars.

I have not heard that the faker was punished. One of his confreres offering the same line of goods recently received the endorsement of a leading official of a great State, who, in lessons he had prepared for the instruction of school children and until their limitations were called to his attention, recommended these appliances as suitable for general use.

Of course, there must be some talking point and an item of reality in connection with all such appliances. The so-called dry powder fire extinguisher will quickly and dramatically subdue a small quantity of gasoline burning in a cuspidor, and it will act similarly with certain other small fires in confined spaces. The point is, we do not have many gasoline fires in cuspidors; we cannot educate our fires to meet the limitations of the specialty extinguisher.

Certain brands of so-called rubber-covered wire, conducting that subtle form of energy, electricity, through the concealed spaces of our houses are sold for about the price of the copper they contain. If any real rubber is used in their coverings the fact has escaped the observation of a number of enlightened investigators.

In fire hose, the arteries and veins of our fire departments, we find manufacturers making a monstrous mystery of their wares, analysts proving them rotten or unfit for use, and gossips busy with tales of scandal about the reasons why inferior hose is delivered when superior is supposed to be paid for from the public treasuries.

But the same degree of acumen which brings profit from unfair dealings is rewarded in larger measure if applied to legitimate trade, and fakes in the fire appliance line are going out of fashion. Beginning with an annual output of a few thousand certified fire appliances, we now have an annual volume of twenty million. Manufacturers and dealers, buyers and users, the constituted authorities and underwriters' boards, the financial interests, and departments of the National Government are all lending their aid and earnest cooperation to this movement.

Perhaps no single agency has had a greater influence in making for these improved conditions than the National Fire Protection Association, an organization unique, I believe, in listing ninety of the principal National Institutes, Societies, Associations and Insurance Boards in America as active members. During the fifteen years of its existence, this Association has worked constantly for conservation of the created resources of America. It believes that the fire waste is of great importance as affecting the material welfare of the nation as a whole.

In the specifications coming under the jurisdiction of this Association, possibly the one best known is the National Electrical Code, which covers the safeguarding of electrical equipment, and which has been adopted as the law of more municipalities and the standard of a greater number of other organizations with authority than any other single set of engineering specifications in existence to-day.

Another publication covers rules for automatic sprinkler installations, outlining in detail the methods to be followed in equipping buildings with this most useful and successful extinguishing agent. Publications of a similar character, which have been distributed in editions of many thousands, and which are freely used by property owners, architects, insurance boards and others interested, include specifications for the construction and installation of fire doors and fire windows, fire shutters, electrical signaling systems affecting the fire hazard, valves and hydrants, hose, suggestion for organizing private fire departments, and various forms of building construction.

Specifications for safeguarding hazardous appliances and systems coming under the general head of Explosives and Combustibles have been issued, including films for moving picture machines, systems for storing fluids which at ordinary temperatures give off inflammable vapors, acetylene gas machines, gasoline vapor gas lighting machines, lamps and systems, engines and stoves, rules for waste cans, ash cans, refuse barrels, fire pails and safety cans for benzine and gasoline, storage and use of fuel oil, kerosene oil pressure systems, and also suggestions for protection against lighting.

*From an address before the 35th Annual Meeting of the Fire Underwriters of the Pacific Coast, Jan. 11, 1911.

†President National Fire Protection Association.

A BUTTING COLLISION on the night of Feb. 4 wrecked a passenger train and a light engine on the Grand Trunk Ry. near Paris, Ont. The baggage and mail cars were demolished and burned. Five persons were killed.

A POWDER MILL EXPLOSION, Feb. 6, at Ishpeming, Mich., in the blasting gelatin house of the Pluto Powder Co. destroyed the building and killed ten men. Reports state that 1,000 lbs. of the gelatin exploded.

THE NEW YORK SUBWAY carried 270,321,490, passengers in 1910, as shown by the sale of tickets reported to the Public Service Commission. In 1905, the first full year of operation, the ticket sales were 116,209,313. The 1910 sales at Brooklyn Bridge Station head the list at 16,688,028, a figure slightly less than for 1909. Borough Hall, Brooklyn, followed with 15,900,312; then the Grand Central station with 13,843,484; Fulton St., Manhattan, with 13,100,949; Fourteenth St., with 12,593,[illegible] Times Sq., with 11,354,365.

BY THE FALL OF AN AEROPLANE from a height of 65 ft., at Döberitz, near Berlin, Germany, on Feb. 7, Lieut. Stein, of the Army aeronautic corps, is reported to have been killed.

A LINCOLN MEMORIAL to be built in the city of Washington at a cost of $2,000,000 is provided for by an appropriation bill which has passed both houses of Congress and is now in the hands of the President. The exact nature of the memorial is to be determined by a special commission, of which the President is the head. It will be remembered that in the plans for the development of the city of Washington made by a special commission some years ago, provision is made for a Lincoln memorial of monumental character in the riverside park just south of the Washington monument.

A CONTRACT FOR THE HUDSON RIVER PRESSURE tunnel of the Catskill Aqueduct will probably be let soon by the Board of Water Supply, New York City. Extensive test borings, both vertical and inclined (see Eng. News, April 2, 1909, and April 7, 1910), have indicated that it will be necessary, or at least wise, to drive the tunnel at a depth of over a thousand feet below the surface of the river.

THE RELIEF FUNDS DEPARTMENT of the Pennsylvania R. R., according to a recently issued bulletin, has a membership of more than 162,000, amounting to nearly 85% of the total number of employees. During the past year, payments to the families of members that died amounted to $839,750, while $1,449,967 were paid to members who were unable to work. This brings the total sum distributed from the relief funds since their establishment some 25 years ago to nearly $30,000,000.

A NEW ORE HANDLING PIER for unloading iron ore has just been completed at Port Richmond, Philadelphia, by the Philadelphia & Reading R. R. The pier is 764 ft. long and 69 ft. wide. Its side walls are of concrete supported on piles. The area between the side walls is filled into a level 15 ft. above low water. Two Brown Hoist automatic ore unloaders are operated on the pier with a capacity of 300 tons per hour.

FEDERAL INSPECTION OF LOCOMOTIVE BOILERS is provided for by the Burkett Bill, which passed the Senate on Jan. 10 and the House on Feb. 7. The bill is approved by the railway brotherhoods, including the locomotive engineers, the firemen, the conductors and the trainmen. It has also been approved by a special committee representing the railway companies and by the American Federation of Labor.

The bill leaves the primary responsibility for locomotive boiler inspection with the railway companies. It provides, however, that the country shall be divided into 50 locomotive boiler inspection districts. In each one of these there is to be a government locomotive boiler inspector receiving an annual salary of $1,800 and traveling expenses, with an annual allowance for rent, stationary and clerical assistance not exceeding $600 as a maximum. These inspectors are to be under the direction of a chief inspector, with a salary of $4,000 and two assistants at $3,000. The railways are required to file their rules and instructions for locomotive boiler inspection with the chief government inspector within three months after the passage of the bill, and such rules, after approval and modification by the Interstate Commerce Commission if necessary, shall become obligatory upon the railway. The reports of inspections made in each locomotive district are to be filed with the Federal inspector for that district, who has power to supervise the work done by the railway companies within his jurisdiction.

The district examiners are to be selected with the aid of civil service examinations and a part of these examinations is to be a list of questions relating to the construction, repair, inspection and testing of locomotive boilers and practical experience therein, this list of questions being prepared by the Chief Inspector.

TO PREVENT DUSTING OF CONCRETE FLOORS already laid the following remedy is recommended by Mr. Albert Moyer, Assoc. Am. Soc. C. E.:

Wash the floor thoroughly with clean water, scrubbing with a stiff broom or scrubbing brush, removing all dirt and loose particles. Allow the surface to dry. As soon as dry apply a solution of one part water-glass (sodium silicate), and three to four parts of water, the proportion of water depending upon the porosity of the concrete. The denser the concrete the weaker the solution required. Stir well, and apply this mixture with a brush (a large whitewash brush with long handle will be found the most economical). Do not mix a greater quantity than can be used in an hour.

If this solution is sufficiently thin, it will penetrate the pores of the concrete. Allow the concrete surface thus treated to dry. As soon as dry, wash off with clean water, using a mop. Again allow the surface to dry and apply the solution as before. Allow to dry and again wash off with clean water, using a mop. As soon

as the surface is again dry, apply the solution as before. If the third coat does not flush to the surface apply another coat as above.

The sodium silicate, which remains on the surface, not having come in contact with the other alkalies in the concrete, is readily soluble in water and can therefore be easily washed off, thus evening up the color and texture of the floor. That which has penetrated into the pores, having come in contact with the other alkalies in the concrete, has formed into an insoluble and very hard material, hardening the surface, preventing dusting and adding materially to the wearing value of the floor.

THE USE OF RAILWAY MAPS to show various classes of information relative to a railway system is illustrated by a pamphlet which was prepared by the Swiss Government Railways for distribution at the International Railway Congress of Berne in 1910. The series of 12 maps is reproduced in the January number of the "Revue Generale des Chemins de Fer. They show the following among other features: (1) The railway system as a whole, and the system of the government and private lines; (2) the maximum speeds authorized on different lines; (3) the connections with foreign railways (at the frontier) for through traffic; (4) the location and extent of double track lines and electrically-operated main lines; (5) the narrow gage railways, rack railways and cable railway railways; (6) the cities having street railways. In some cases the map shows only one special feature, but it is easy to include two or more different but related features (such as those noted under group No. 5), by the use of different symbols.

MORE QUEBEC BRIDGE EXPERTS.—The Canadian authorities have appointed Mr. Henry W. Hodge, of the firm of Boller & Hodge, Consulting Engineers, New York City, and Mr. M. J. Butler, former Deputy Minister of the Department of Railways & Canals and now General Manager of the Dominion Iron & Steel Co., of Sydney, Nova Scotia, as advisory experts to aid the Quebec Bridge Board in its present difference of opinion. It is understood that the Board has reached a disagreement over the plans submitted in response to its call for bids, and the two additional experts are to aid in reaching a conclusion upon the question.

THE LENGTHS OF ALPINE RAILWAY TUNNELS and their elevations above sea level are given as follows in the "Revue Generale des Chemins de Fer":

Tunnel.	Length, miles.	Altitude, ft.	
Simplon	12.28	2,312	(9)
Gotthard	9.29	3,785	(6)
Lotschberg	9.01	4,064	(4)
Cenis	7.97	4,248	(3)
Arlberg	6.35	4,297	(2)
Ricken	5.33	2,034	(10)
Moutier-Granges	5.31	1,788	(11)
Tauern	5.30	4,018	(5)
Hauenstein	5.05	1,483	(12)
Mont d'Or	3.83	2,942	(7)
Albula	3.64	5,979	(1)
Weissenstein	2.26	2,532	(8)

A BRAKE TO REDUCE THE ROLLING OF SHIPS was described in a paper before the recent meeting of the Naval Architects' Society of Germany, by Mr. H. Frahm, of Hamburg. London "Engineering" describes the device as follows:

Rolling tanks are an invention developed by Mr. Frahm at the yard of Messrs. Blohm and Voss. Rolling motions imparted to a vessel by wave impulses are damped automatically by means of masses of water which are caused to oscillate in a U-shaped tank arranged athwartships. The tank is in two parts, one at each side of the vessel, connected by a horizontal pipe. The dimensions are such that the period of oscillation of the water is the same as that of the vessel. The arrangement was first tried in the summer of 1909 in the very stiff fuel-oil vessel "W. 83" of the Imperial German Navy, which was placed at the inventors' disposal for the purpose. The very small tanks which could be applied to this vessel reduced her amplitude of rolling by two-thirds. A second experiment in the spring of this year made on a fast vessel of 18,500 tons displacement, again with tanks relatively too small, reduced the amplitude of roll by 44%. The most important trials of the invention were made on two very heavy rollers of the Hamburg-American Line, the "Ypiranga" and "Corcovado." Trials on the "Ypiranga," made in the Bay of Biscay in presence of a number of nautical and shipbuilding experts, having demonstrated the excellent effect of the tanks, the sister vessel "Corcovado" had likewise been fitted with the apparatus. In the course of last summer, records had been taken on voyages of these vessels between Lisbon and Buenos Aires, respectively, and Hamburg in all sorts of weather, sometimes with and sometimes without the apparatus in action. Oscillations of 11° to each side were reduced to 2°. On the voyages in question the effect of the tanks on the comfort of the passengers was found to be exceedingly marked, and with these results in view the Hamburg-American Line determined to fit the apparatus in its next large passenger steamer of over 35,000 tons displacement. The weight of water necessary for the tanks of a large vessel of this kind varies between 0.6 and 1.5% of her displacement, and the water need be carried only when bad weather is experienced or expected.

A NAVIGATION CHANNEL between Lake Superior and the Mississippi River is recommended by a State Commission appointed in Minnesota in 1909. The Commission's recommendations are as follows:

1. We find that the construction and operation of a canal from the head of Lake Superior to upper Mississippi River is feasible.
2. We find the distance from Fond du Lac, at the head of St. Louis Bay, to the Mississippi River, near Sandy Lake, according to the government engineer's report, to be 68 miles.
3. We find by the same engineer's report that the construction of a 7-ft. barge canal would cost $9,762,457, and that a steamboat canal would cost in round numbers $16,000,000.
4. We find the distance by the Mississippi River to be, from Sandy Lake, the proposed junction of the canal, to St. Paul, 255 miles.

While it may be beyond the requirements of this commission to recommend certain action by your legislative body, we beg your indulgence in making the following recommendation:

1. That you make an appropriation of $5,000 for the purpose of clearing out the dead and sunken logs now impeding and making dangerous transportation on the Upper Mississippi River above Little Falls.
2. We would further ask that you make an appropriation of fifteen thousand ($15,000) dollars, or so much thereof as may be necessary to prosecute a survey of the Upper Mississippi from St. Paul to Sandy Lake, and to obtain the approximate cost of locks and dams that would afford slack water navigation for steamboats drawing 7 ft. of water.
3. We ask that your honorable body will, in its legislative acts, provide for and create a fund to be known as "The Lake Superior and Mississippi River Transportation Improvement Fund," and further suggest that a portion of said fund could be made up advantageously without resorting to the levy of taxes, by requiring that 5% of all the revenues derived from the gross earnings tax from all corporations and public utilities be set aside for that purpose.

Personals.

Mr. George L. Carter has resigned as President of the Carolina, Clinchfield & Ohio Ry. to engage in private business. He is succeeded as President by Mr. M. W. Potter, Chairman of the Board of Directors.

Mr. Frederick H. Lewis, M. Am. Soc. C. E., formerly Vice-President and General Manager of the Standard Portland Cement Co., of Leeds, Ala., has opened an office at 732 Brown Marx Bldg., Birmingham, Ala., as a consulting engineer.

Mr. Henry W. Thornton, formerly Superintendent of the Erie & Ashtabula Division of the Pennsylvania R. R. at Newcastle, Pa., has been appointed Assistant General Superintendent of the Long Island R. R., with headquarters at Long Island City, N. Y.

Mr. George R. Henderson, M. Am. Soc. M. E., who went to Brazil a year ago to advise regarding the equipment of a Brazilian railway, returned to the United States last August and is now Mechanical Engineer of the Baldwin Locomotive Works, Philadelphia, Pa.

Mr. Charles Strauss, of the law firm of Strauss, Reich & Boyer, has been appointed by Mayor Gaynor a member of the Board of Water Supply of the City of New York. Mr. Strauss was a member of the Board of Education for ten years, and is a trustee of the College of the City of New York.

Mr. J. D. Trammell, City Engineer of Fort Worth, Tex., has resigned to become Chairman of the Board of Engineers who will supervise the construction of a new reservoir for the city. The other members of the board are Mr. John B. Hawley, M. Am. Soc. C. E., a consulting engineer of Fort Worth, and Prof. T. U. Taylor, M. Am. Soc. C. E., of the University of Texas.

The following changes in the New York State Barge Canal personnel have been announced by State Engineer John A. Bensel: Mr. John A. O'Connor, Assoc. M. Am. Soc. C. E., formerly Resident Engineer, to be Division Engineer of the Eastern Division, succeeding Mr. George D. Williams; Mr. Carleton Greene, Assoc. M. Am. Soc. C. E., of the firm of Greene & Greene, Consulting Engineers, of New York City, to be Resident Engineer at Schenectady, to succeed Mr. E. J. Pickwick, Assoc. M. Am. Soc. C. E., and Mr. Earl Talbot, Assoc. M. Am. Soc. C. E., of New York City, to be Resident Engineer at Utica, to succeed Mr. S. M. Savage, Assoc. M. Am. Soc. C. E.

John F. Gaynor and Benjamin D. Greene, who were convicted of conspiracy with ex-Captain O. M. Carter to defraud the Government in the Savannah Harbor contracts, have completed their four years' sentence in the Atlanta penitentiary, deducting the time allowed prisoners for good behavior during confinemept. A fine of $575,000 still hangs over them and it has been currently reported that at the end of 30 days they would take a pauper's oath and secure their release. Press dispatches from Atlanta, Feb. 6, however, stated that the Government contends that the prisoners have concealed in the hands of third parties a large part of the money which they secured through their fraudulent operations, and that if they attempt to escape payment of the fine by taking a pauper's oath, they will be at once arrested for perjury.

The Chicago, Rock Island & Pacific Ry. has divided its operating departments into three districts and announce the following changes: Mr. W. H. Peterson, formerly Principal Assistant Engineer at Chicago, Ill., to be Engineer of Maintenance-of-Way of the first district with headquarters at Davenport, Iowa; Mr. J. M. Brown, formerly District Engineer at Davenport, to be Engineer of Maintenance-of-Way of the second district at Topeka, Kan., and Mr. A. B. Warner, formerly District Engineer at El Reno, Okla., to be Engineer of Maintenance-of-Way for the third district, with headquarters at the same place. In the mechanical department the following changes have taken place: Mr. J. B. Kilpatrick, formerly Superintendent of Motive Power at Chicago, Ill., is Superintendent of Motive Power of the first district at Davenport, Iowa; Mr. S. W. Mullinix, formerly Superintendent of Motive Power at Horton, Kan., is Superintendent of Motive Power for the second district at Topeka, Kan., and Mr. C. M. Taylor, Superintendent of Motive Power at Shawnee, Okla., is to have charge of the third district with the same headquarters.

Obituary.

James Fulton Elder, for many years an official of the Pennsylvania R. R. and connected with the development of the air-brake and other railway appliances, died at his home in Philadelphia, Pa., on Jan. 30, at the age of 75 years.

John A. Clarke, of the purchasing department of the Canadian Pacific Ry., died in a private car at Windsor Station, while enroute to Montreal, on Feb. 5. He was 63 years old. His death was the direct result of a fall on the sidewalk while attending the funeral of the late J. E. Schwitzer, Chief Engineer of the Canadian Pacific Ry. Following the fall he had a hemorrhage of the brain and did not recover consciousness to the time of his death, ten days later.

Mr. Roderick McLennan, a civil engineer of Toronto, Ont., died at his home in that city on Feb. 2, at the age of 88 years. His early engineering experience was had in the Southern United States, previous to and during the Civil War. In 1864, while attempting to leave the States he was arrested and confined for 13 weeks at Dry Tortugas, Fla. On returning to Canada he was engaged on the surveys and construction of the Intercolonial Ry. in British Columbia, and later with Canadian Pacific Ry. in the vicinity of Winnipeg, Man.

Charles S. Sperry, Rear Admiral U. S. N., retired, died in Washington, D. C., on Feb. 1, from pneumonia, at the age of 63 years. He was born in Brooklyn, N. Y., and graduated from the Naval Academy at Annapolis in 1866. He reached the rank of Rear-Admiral in 1906 and was the commander, succeeding Rear Admiral Evans, who conducted the battleship fleet on the famous world tour, completed a few years ago. He had been President of the Naval War College and represented the United States at The Hague Conference in 1906. He was considered an authority on international law.

Edward Lafayette Russell, Vice-President and General Counsel of the Mobile & Ohio R. R., died from pneumonia at the Raleigh Hotel in Washington, D. C., on Jan. 28. He was born in Franklin County, Ala., on Aug. 19, 1845. He served throughout the Civil War in the 41st Mississippi Regiment of the Confederate Army. He was appointed General Solicitor of the Mobile & Ohio R. R. in 1875. He was made Vice-President of the same road in 1897, and in 1898 President. Soon after this time the Mobile & Ohio was absorbed by the Southern Ry., and he became Vice-President and General Counsel of the subsidiary company.

Louis R. Alberger, M. Am. Soc. M. E., President of the Alberger Condenser Co. and the Alberger Pump Co., of New York City, died at the Roosevelt Hospital in New York City, following an operation for hernia, on Jan. 31. He was born in Buffalo, N. Y., on April 10, 1864. After attending Yale University he entered business with his father, J. L. Alberger, then engaged in the manufacture of apparatus used in the vacuum process of the salt industry. He came to New York City in 1887 and for some years worked under Henry R. Worthington in the manufacture of pumping machinery. In 1901, he organized the Alberger Condenser Co., and a few years later the Alberger Pump Co. He was a prominent yachtsman and a member of the New York Yacht Club and also a member of the Engineers' Club.

Frederick Godfray Hesse, Professor Emeritus of Hydraulics at the University of California, died at his home in Oakland, Cal., on Jan. 27. He was born at Treves in Prussia in 1825. He studied in his native city until 1845 when he entered the Royal Polytechnic School at Berlin. With many other of his countrymen he left his native home during the revolution of 1848 and settled in America. He immediately entered upon engineering work, first as an instructor at Brown University in Providence, R. I., and later with the Philadelphia & West Chester R. R. He went to the University of California in 1875 and had been connected with the College of Mechanical Engineering ever since that time. He was chiefly noted for his engineering work in connection with the development of the Pelton water-wheel and other hydraulic devices.

Dr. Leonard Parker Kinnicutt, Director of the Department of Chemistry of the Worcester Polytechnic Institute, died at his home in Worcester, Mass., on Feb. 6, from tuberculosis and heart disease. He was born in Worcester on May 22, 1854. He graduated from Massachusetts Institute of Technology in 1875, where he had been one of the most popular and fun-loving of his class. From 1875 to 1879 he studied at the famous German University of Heidelberg, under Prof. Bunsen, and at Bonn under Prof. Kekule. From 1879-1880, he studied at John Hopkins University, and from 1880 to 1882 at Harvard University, where he received the degree of Doctor of Science. He was an instructor in Chemistry at Harvard until the following year when he went to the Worcester Polytechnic Institute as Assistant Pro-

fessor of Chemistry. In 1886 he became Professor and later Director of the Department of Chemistry.

In point of service Dr. Kinnicutt was one of the oldest of the present Institute faculty and certainly one of the best beloved of the students and alumni, every one of whom could claim acquaintance with him. Many a now prominent engineer will remember the doctor's good services in extraditing him from an unhappy school-boy scrape.

Aside from his work as teacher Dr. Kinnicutt early obtained prominence as a consulting chemist, especially in sanitary matters. He was connected for many years with the experiments and daily operation of the Worcester sewage disposal works, which are famous in the sanitary engineering annals of this country. In 1892 he was Consulting Chemist of the Connecticut Sewerage Commission. He was frequently engaged in special work for municipalities and commissions. He was one of the expert witnesses who testified as to the quality of the water of the Mississippi River, and the effect of the Chicago Drainage Canal on it as a source of water-supply for the city of St. Louis.

Dr. Kinnicutt was one of the best-known of American scientists to men who were engaged in similar work in Europe. It was his custom to travel abroad every other summer, and in recent years even more frequently, to study the sewage-disposal works and developments in England and on the Continent, where he had many friends among his former schoolmates and instructors. He was a member of the London Chemical Society, the Deutsche Chemische Gesellschaft and other foreign professional societies. In this country he was a member of the American Chemical Society, a fellow of the American Academy of Arts and Sciences, a member of the Society of Chemical Industry, the New England Water Works Association, the Boston Society of Civil Engineers and many other scientific organizations.

He was a member of a prominent New England family and a brother of Dr. Francis P. Kinnicutt, of New York City, Professor of Clinical Medicine at Columbia University. He leaves a widow.

He was the author of many professional papers published in the transactions of the various societies and a contributor to scientific journals. His crowning work as a writer was his joint authorship (with Prof. C.-E. A. Winslow and R. Winthrop Pratt) of "Sewage Disposal," published in the latter part of 1910.

Engineering Societies.

COMING MEETINGS.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS.
Feb. 14-15. Annual meeting at New London, Conn. Secy., J. Frederick Jackson, New Haven, Conn.

NEW ENGLAND ASSOCIATION OF GAS ENGINEERS.
Feb. 15. Annual meeting at Boston, Mass. Secy., N. W. Gifford, 26 Central Square, East Boston, Mass.

IOWA ENGINEERING SOCIETY.
Feb. 15-17. Annual meeting at Des Moines, Iowa. Secy., S. M. Woodward, Iowa City, Iowa.

NORTHWESTERN CEMENT PRODUCTS ASSOCIATION.
Feb. 28-March 1. Annual convention at Minneapolis, Minn. Secy., Harvey B. Smith, 834 Security Bank Bldg., Minneapolis, Minn.

CANADIAN MINING INSTITUTE.
March 1-3. Annual meeting at Quebec, Que. Secy., H Mortimer Lamb, Windsor Hotel, Montreal, Que.

CANADIAN CEMENT AND CONCRETE ASSOCIATION.
March 6-11. Annual convention at Toronto, Ont. Secy., Wm. Snaith, 57 Adelaide St., East, Toronto, Ont.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 21-23. Annual convention at Chicago, Ill. Secy., E. H. Fritch, 962 Monadnock Block, Chicago, Ill.

ENGINEERING SOCIETY OF WISCONSIN.
March 1-3. Annual meeting at Madison, Wis. Secy., W. G. Kirchoffer, Vroman Bldg., Madison, Wis.

ILLINOIS WATER SUPPLY ASSOCIATION.
Feb. 21-22. Annual meeting at the University of Illinois. Secy., E. Bartow, Urbana, Ill.

IDAHO SOCIETY OF ENGINEERS.—The second annual meeting will be held in Twin Falls, Idaho, Feb. 16-18. The secretary is Gordon C. Smith, Boise, Idaho.

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.—The result of the ballot for officers for the coming year was announced at the annual meeting, held in New York City, Jan. 25, as follows: President, Henry W. Vogel; Vice-Presidents, Sidney W. Hoag, Jr., and Frederick C. Noble; Secretary, C. D. Pollock; Treasurer, Herman K. Endemann; Directors, A. L. Schaeffer, E. M. Law, Jr., D. L. Turner, E. A. Miller and E. J. Fort.

MONTANA SOCIETY OF ENGINEERS.—At the 24th annual meeting, held at Helena, Jan. 12-14, officers were elected as follows: President, F. W. C. Whyte; Vice-Presidents, Robt. A. McArthur and John H. Klepinger; Secretary, Clinton H. Moore; Treasurer; Samuel Barker, Jr. Preliminary action was taken toward changing the date of the annual meeting to the second Saturday in April.

SOUTH DAKOTA ENGINEERING SOCIETY.—An organization under this name was effected at Pierre, S. Dak., in the last week of January. The object of the new society is announced as the advancement of engineering knowledge and practice in the State and the maintenance of a high professional standard among its members. Officers have been elected as follows: President, S. E. Lea, Pierre; Vice-President, A. B. McDaniel, Vermillion; Secretary-Treasurer, R. G. Culbertson, Mitchell.

BROOKLYN ENGINEERS CLUB.—The regular monthly meeting will be held at the club-house on Feb. 9. Mr. Daniel B. Goodsell of the Bureau of Highways of the Borough of Manhattan will read a paper entitled "The Pavement Problem of the Borough of Manhattan." The paper will be illustrated by lantern slides and will cover in detail the problem of repaving and repairing the city's busy streets.

The annual club smoker will be held on Saturday evening, March 25, when the usual good time is expected.

AMERICAN SUPPLY AND MACHINERY MANUFACTURERS' ASSOCIATION.—The annual meeting will be held in Louisville, Ky., April 3-5. At the same time and place will be held the meetings of the National Supply and Machinery Dealers' Association and the Southern Supply and Machinery Dealers' Association.

MISSISSIPPI ELECTRIC ASSOCIATION.—A meeting of this association, which represents the central station industry of Mississippi, was held at Meridian Jan. 19, at which it was decided to affiliate with the National Electric Light Association.

TREASURY CONSTRUCTION SOCIETY.—The second annual meeting was held in St. Louis, Mo., Jan. 27-28. About 30 members were present. Papers were read by H. G. Richey, H. A. R. Gray, T. R. Maul, Richard Fourchy and others. Officers were elected as follows: President, A. A. Packard, Chicago, Ill.; Vice-Presidents, Richard Fourchy, Kansas City, Mo., and N. S. Thompson, Washington, D. C.; Secretary-Treasurer, T. R. Maul, 234 Walnut St., Philadelphia, Pa.; Corresponding Secretary, B. S. Appleyard, Ottumwa, Iowa.

This society is composed of officials and employees of the Supervising Architect's Office, U. S. Treasury Department. Its organization was noted in Eng. News, Feb. 3, 1910.

IOWA ENGINEERING SOCIETY.—The 23d annual meeting will be held Feb. 15-17 at Des Moines, Ia. The program includes a symposium on the subject of statutory regulation of engineering work: (1) state licensing of civil engineers, by T. R. Warriner; (2) state control of road and bridge work, by W. G. Raymond; (3) state control of sanitary engineering, by Lafayette Higgins; (4) state control of stream improvements, by Anson Marston.

The list of papers includes the following: "Setting Permanent Corners in Towns and Cities," R. B. Slippy; "Road Building in Germany," B. Schreiner; "Concrete Paving in Mason City, Ia.," F. P. Wilson; "The Recent Typhoid Epidemic in Des Moines, Ia.," Lafayette Higgins; "Sewage Disposal and Purification," C. P. Chase; "Cement Drain Tile," A. J. Lilly; "Tests for Drain Tile and Sewer Pipe," Anson Marston; "Sewer Construction," L. H. Stone; "The New Rapid Sand Filters at Iowa City," John H. Dunlap; "Water Power Development in Iowa," A. H. Ford;; "Relative Merits of Different Kinds of Pavement," M. L. Patzig; "The Manufacture of Portland Cement," Geo. P. Dieckmann; "Tile Drainage," J. L. Parsons; "Public Work versus Politics," K. C. Gaynor.

WESTERN SOCIETY OF ENGINEERS.—The officers of the three special sections of the society for 1911 are as follows: (1) Bridge and Structural Section; Chairman, John Brunner; Vice-Chairman, F. E. Davidson. (2) Hydraulic, Sanitary and Municipal Section; Chairman, L. K. Sherman; Vice-Chairman, C. B. Burdick. (3) Electrical Section; Chairman, G. T. Seely; Vice-Chairman, J. R. Cravath.

Beginning with January, 1911, the society is publishing its "Journal" every month instead of every two months. The first number under the new plan has 82 pages and contains two important papers: "Paints and Pigments," by A. H. Sabin; and "Electrostatics and Electric Impulse Forces," by Dr. Charles P. Steinmetz.

At the meeting on Feb. 1, a paper by John M. Ewen and A. Bement was read on the subject "The Public and the Public Service Corporation." It discussed briefly and friction between these two parties in public affairs, and stated that while there has been a tendency on the part of the former to approve of competition between public-service corporations, experience has shown that such competition results usually in increased cost of service to the consumers. For the proper control of corporations having monopolies the paper suggested the establishment of commissions comprising both business men and engineers (and some engineers combine both qualifications). It was not proposed to have one commission to deal with the problems of all public utilities, but to have one for each character of service. The excellent results of the Board of Supervising Engineers (having control of the street railway system of Chicago) were cited as supporting the suggestion made in the paper.

At the meeting of the Hydraulic, Sanitary and Municipal Section of the society, on Jan. 30, two papers were presented relating to the sewage problems of Chicago. Mr. C. D. Hill dealt with "The Sewage System of Chicago," and Mr. Langdon Pearse dealt with "The Sewage Disposal Problem."

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The program for the coming mid-year convention, Feb. 14-16, at Pittsfield, Mass., and Schenectady, N. Y., contains the following papers: Feb. 14, at Schenectady, "High Tension Testing of Insulating Materials," A. B. Hendricks; "Hysteresis and Eddy Current Losses for Silicon Steel," W. J. Wooldridge; "Commercial Problems of Transformer Design," H. R. Wilson; "Design, Construction and Tests of an Artificial Transmission Line," J. H. Cunningham; "Protection of Electrical Transmission Lines," E. E. F. Creighton; "Tests of Grounded Phase Protector on the 44,000-Volt System of the Southern Power Co.," C. I. Burkholder and H. H. Marvin; "Tests of Losses on High Tension Lines," G. Faccioli. Feb. 15, at Pittsfield, "Mechanical Forces in Magnetic Fields," C. P. Steinmetz; "Problems in the Operation of Transformers," F. C. Green; "The Regulation of Distributing Transformers," C. E. Allen; "Temperature Gradient in Oil-Immersed Transformers," M. Weed; "Dissipation of Heat from Self-Cooled, Oil-Filled Transformer Tanks," J. J. Frank and H. O. Stephens. Feb. 16, at Schenectady, "Oil Break Circuit Breakers," E. B. Merriam; "Proposed Applications of Electric Ship Propulsion," W. L. R. Emmet; "Voltage Regulation of Generators," H. A. Laycock, "Briefs on Vector Rotation," E. J. Berg and W. S. Franklin.

The technical sessions at Schenectady will be held at the Mohawk Golf Club. The Pittsfield session will be held in Lenox Hall.

In place of the usual annual dinner, a reception and ball will be held at the Hotel Astor, New York City, Feb. 28. A feature will be the presentation of past-presidents' badges. A number of the past-presidents of the Institute are expected to be present.

A new local section of the Institute was organized at a meeting held at Detroit, Mich., Jan. 28. The initial membership of 48 is divided between Detroit, Ann Arbor and Jackson. Meetings will be held monthly, alternating between Detroit and Ann Arbor. Officers were elected as follows: Chairman, C. L. de Muralt, Ann Arbor; Vice-Chairman, H. M. Browne, Detroit; Secretary-Treasurer, B. F. Bailey, Ann Arbor; Assistant Secretary, J. J. Woolfenden, Detroit.

AMERICAN INSTITUTE OF CONSULTING ENGINEERS.—An amended constitution was adopted at the annual meeting, held Jan. 17 at the Engineers' Club, New York City. The Institute was formed a year ago out of a local association of consulting engineers which had existed since 1905. The objects which now govern its work are stated in the new constitution as

> the promotion of ethical standards and practical efficiency in all branches of engineering as a profession.

It is understood that the Institute will not deal with technical papers and discussions, but will occupy itself with matters affecting the status of the engineer as a professional man, as: legislation affecting practice of engineering, rules of professional conduct, and standard charges for engineering service. For the present the first two subjects have been taken in hand. The committees which have them in charge are: On Legislation, Gen. T. A. Bingham (ch.), S. O. Miller, and S. Whinery; On Professional Practice and Ethics, John F. Wallace (ch.), H. W. Hodge, F. A. Molitor, L. B. Stillwell, Geo. F. Swain, W. J. Wilgus.

The character of the Institute is further expressed in its membership qualifications:

> The membership of this Institute shall be limited to those actively engaged in the independent practice of the profession of Engineering in any of its branches as Consulting Engineers, and who are not engaged in contracting.
>
> A candidate to be eligible for membership must be at least 35 years of age, must be a full member in good standing of one or more of the four largest national engineering societies (Civil, Electrical, Mechanical or Mining) or have been an Engineer Officer of the United States Army or Navy, and must be of high character and professional reputation.

Members are elected by the Council, which largely governs the Institute, electing all the officers. One-third of the Council is elected each year by the Institute. The Council as elected at the meeting of the past month consists of: Gustav Lindenthal, Ralph Modjeski, John F. Wallace, Gen. T. A. Bingham, Rudolph Hering, C. O. Mailloux, Alfred P. Boller, J. E. Greiner and C. C. Schneider. The officers for the coming year are: Alfred P. Boller, President; Gustav Lindenthal, Vice-President; E. W. Stern (103 Park Ave., New York), Secretary and Treasurer.

The Institute at present has 38 members, nearly all of whom are prominent engineers. A considerable growth is expected during the next year, in view of the great importance of the Institute's objects and the fact that no body now concerns itself with the professional side of engineering. The membership list is not too long to quote here. Besides the Council members and officers it includes: Gunvald Aus, R. P. Bolton, H. R. Buck, F. A. Burdett, E. L. Corthell, J. Vipond Davies, A. M. Feldman, Geo. W. Fuller, E. P. Goodrich, H. W. Hodge, Olaf Hoff, C. M. Ingersoll, Geo. E. Low, L. B. Marks, R. P. Miller, S. O. Miller, F. A. Molitor, H. W. Post, W. F. Scott, Mason R. Strong, George F. Swain, L. B. Stillwell, T. K. Thomson, S. A. Thompson, W. J. Wilgus, Samuel Whinery, J. A. L. Waddell and J. R. Worcester.